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ABSTRACT

A survey of 531 electrical engineering graduates of the University of Alabama who had received bachelor's degrees in the years 1950 through 1974 showed that the educational needs of a majority of the respondents could have been adequately served by the mathematics levels present in the engineering technology program. In addition, certain subjects not required in the engineering curriculum but included in the engineering technology program were considered extremely important by the practitioners. Thus, it appears that the philosophy of engineering technology education, with its reduced emphasis upon mathematics and its orientation to practice, might indeed be more appropriate for a major portion of positions now classified as engineering rather than engineering technology. (BB)

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Abstract of a Major Applied Research Project Presented to Nova University in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

A COMPARATIVE STUDY OF PROFICIENCIES UTILIZED BY ELECTRICAL ENGINEERING GRADUATES OF THE UNIVERSITY OF ALABAMA AND THE CORE CURRICULA IN ELECTRICAL ENGINEERING AND ELECTRICAL ENGINEERING TECHNOLOGY

by

William S. Byers

1976

For some time there has been a lack of integration between the objectives of engineering education and the practice of engineering experienced by graduates. Compounding the problem is the emergence of Baccalaureate programs in Engineering Technology and the widespread confusion that exists for the role of such programs and their graduates. Industry, in general, does not recognize the distinctions between Engineering and Engineering Technology envisioned by educators.

Engineering Technology education is relatively new to the State of Alabama. Baccalaureate programs in Engineering Technology were begun at the University of Alabama at Tuscaloosa in 1972 and the spring of 1976 will see the first graduating class. The identity problem that exists for Engineering Technology in general, while perhaps different in detail, has not been escaped by the new programs. Prospective graduates have been greeted by a wide range of cordiality from industry recruitment personnel conducting on-campus interviews. However,

confusion or lack of understanding is also not unknown internal to the University among students and faculty.

The characteristics most prominent in distinguishing the Engineering Technology curriculum from that for Engineering are the level of mathematics required for entry, the subsequent emphasis on mathematics in required courses, and in the application of the techniques of mathematics to the technical specialty. Calculus is nominally the terminal level in technology while it is the entry level in engineering. Technology education generally intends to teach the application of known principles rather than derivation or discovery of new solutions. Such emphasis has been defined by educators as appropriate training for the "Technologist" i.e. one who works in support of engineers and engineering activities.

Engineering education beginning in the 1950's experienced a nationwide movement to a stronger math and science base and the elimination of skill or practice oriented courses. The past few years have seen criticisms from industry that the colleges and universities have gone too far in emphasizing math and science at the expense of practical application. Practicing engineers have had little influence in determining the course of engineering education with most industry participation provided through "high level" representatives.

For purposes of this study, it was hypothesized that perhaps the philosophy of engineering technology education, with its reduced emphasis upon mathematics and its orientation to practice, might indeed be more appropriate for a major portion of positions now classified as engineering rather than engineering technology. To test the hypothesis, it was proposed that electrical engineering graduates, currently employed in industry, would be queried relative to their utilization and need for subject matter contained in the Electrical Engineering and the Electrical Engineering Technology curricula. Mathematics was chosen as an indicator since it is the characteristic most prominent in distinguishing the two types of programs.

A survey instrument was used to explore the occupational status and the level of experience of the recipient as well as attitudes each held for various activities or subjects involved in their employment. The instrument was applied to 531 Electrical Engineering graduates of the University of Alabama who had received Bachelor's degrees in the years 1950 through 1974. Questionnaire returns were analyzed and compared with related characteristics of the core curricula. The survey results indicated that the educational needs of a majority of respondents could have been adequately served by the mathematics levels present in the technology program. It was also indicated that certain subjects, not required in the engineering curriculum but included for technology, were considered extremely

important by the practitioners.

The information derived as a result of this study is considered to have high potential value for substantiating future recommendations affecting curricula updating and development. Objectives of the technology programs may be specified with greater confidence than otherwise possible. On the basis of the findings of this study, the following recommendations are made:

1. That the curriculum in Electrical Engineering Technology at the University of Alabama be revised to more fully exploit the subject emphasis highlighted by this study.
2. That essential results of the study be used in student counseling.
3. That Electrical Engineering students be advised to elect courses that this study has shown to be highly relevant to industry practice and that are not otherwise included in their degree program.
4. That a comphrehensive study be initiated at the national level to define the relationships between engineering practice and the spectrum of mathematics necessary in the preparation of engineers and technologists. Industry participation at the practitioner level should be encouraged. Criteria for curricula and their accreditation should be aimed toward

compatibility with the requirements of practice.

5. That consideration and further study be given to the desirability of a four-year engineering technology oriented program as the first engineering degree with graduate study available to those seeking a specialization or "in depth" concentration.
6. That studies be initiated having objectives of redefining Engineering Technology and its role. Much confusion regarding engineering technology derives from definitions originated prior to the emergence of the Baccalaureate programs in Engineering Technology.

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Chapter I

INTRODUCTION

Employers often classify positions as engineering positions although the incumbents may not be engineering graduates. Government agencies, such as the Census Bureau, classify people by job title or self-description, not educational background and so the total number of engineers recorded is always much higher than the number of graduates. In 1970, of the population classified as holding engineering positions, approximately 62 percent were graduates. Of the 766,100 engineers who were graduates, approximately 24 percent had their highest degree in a field other than engineering. (MIT, 1975, p. 13)

These statistics are significant in relation to the recent emergence of Baccalaureate programs in Engineering Technology, and the widespread confusion that exists for the role of such programs and their graduates. Although the contradiction whereby large numbers of non-engineering graduates may hold "engineering" positions is often ignored, considerable controversy rages over the prospect that Engineering Technology graduates may be allowed to be called "engineer" or to hold positions similar to those held by engineering graduates. Also,

much time is consumed arguing the merits of allowing Engineering Technology graduates to seek registration as Professional Engineers. (Miner, 1976)

Engineering Technology education is relatively new to the State of Alabama. Baccalaureate programs in Engineering Technology were approved by the Alabama Commission on Higher Education for the University of Alabama in the fall of 1971. In the spring of 1972, the University announced the establishment of programs in Civil Engineering Technology, Electrical Engineering Technology, and Mechanical Engineering Technology. These programs were developed as four-year programs requiring 128 semester hours of work leading to the Bachelor of Science degree in the respective fields of Engineering Technology. The programs were initiated and expanded on a year by year basis so that the spring of 1976 should see the first graduates of these programs.

Students in Engineering Technology still form a significant minority in the College of Engineering. Current total enrollment in the Technology area is only eleven percent of that in Engineering. There are thirty-three students in Electrical Engineering Technology as compared to 198 in Electrical Engineering. The identity problem for Engineering Technology students in general, while perhaps different in detail, is shared at the University of Alabama. The role of the Engineering Technology programs is not always understood and graduates are yet to emerge and establish a

record of achievement and acceptance. The programs' objectives and curricula are not yet entrenched in tradition and the opportunity for modification and improvement still exists.

Typically, engineering educators have determined the course of study for Engineering and Engineering Technology programs; practicing engineers have had little influence. Most industry participation has been provided through "high level" representatives. Therefore this study sought the participation of practitioners to supply data that might help to alleviate confusion and provide recommendations for change.

Background of the Problem

Engineering curricula have undergone much perturbation. In addition to the changes required to keep curricula abreast of new technology, there have been major changes in the philosophy of engineering education. The most drastic occurred in the 1950's with a nationwide movement to a stronger science and math base for the engineering programs (Lear, 1975). After World War II university based engineering education programs began to eliminate practice oriented courses and to emphasize mathematics and physical science. It was eventually concluded by engineering educators that a Master's degree should be considered the basic professional degree in engineering (ASEE, 1968). Industry however, has not always accepted

the viewpoint of educators. In general, the practitioners of engineering have had little involvement in the development of engineering education (Irwin, 1974, p. 29). Major support for the Master's degree as the entry level for the new entrants into industry has not been forthcoming (ibid., p. 26). The past few years have seen segments of industry complaining that the universities have gone too far in emphasizing math and science at the expense of the practice oriented courses. There has been a trend toward decline of engineering enrollments and students have often experienced difficulty in obtaining graduate support or the jobs they expected (MIT, 1973). Also, patterns of defense or government spending have shifted drastically. Support for "war" approach research and development (R & D) has stopped; "The military and space R & D budgets have declined as a percentage of all research and the National Institutes of Health have recently suffered severe cutbacks" (ibid, p. 9). As a result there has been growing uneasiness in engineering schools for the long range future of their programs, enrollments, and ultimate product.

In the meantime, technical institutes have been providing their own type of practice-oriented programs. Their curricula had gradually evolved into two years for the awarding of an Associate degree and by 1955 some thirty institutions provided ninety three curricula. By 1968, the American Association of Junior Colleges reported that approximately 300 Community Colleges offered organized curricula in

engineering technology or a closely related field. Recently a new stream of technological education has emerged in the form of four year baccalaureate programs in engineering technology. The first Technology Bachelor's program was accredited by 1968 and as of 1974 there were 101 (ECPD, 1974, p. 11). Many of these programs were originally conceived to provide advanced third and fourth year training for technically oriented Associate degree graduates. However other variations have developed including an integrated four year university degree program.

Engineering Technology curricula have many similarities and differences when compared to those of Engineering. The most prominent characteristic of Engineering Technology is a diminished entry level requirement for mathematics preparation and aptitude. Philosophically, subsequent courses emphasize math application rather than derivation. In general, calculus serves to differentiate the two programs. Calculus is the entry level requirement for engineering while it is nominally the terminal level attainment in technology. There are some exceptions in that differential equations or some other higher level math forms may be found in electrical engineering technology programs.

The reduced emphasis upon mathematics has generally been given credit for the rapid growth of technology programs. Many young people, although attracted to a technical career, may be counseled away from engineering because of its math aptitude requirement. Engineering technology opens the door

to many technically oriented high school graduates who may not be prepared for or interested in the heavy mathematical emphasis of the engineering curriculum. Thus, the growth of technology programs is not believed to have significant effect toward reducing enrollments in engineering programs (ASEE, 1972, p. 33).

Considerable confusion and misunderstanding exists in industry and among educators concerning the roles to be played by engineering or engineering technology programs and by their respective graduates. For example, "Engineering Technology" as a curriculum designation is used for both two and four year programs. However, graduates of technology programs are usually classified as technicians (two year) or technologists (four year) according to the length of the educational program and the degree awarded. These terms are not recognized or generally understood by industry (Baker, 1974). Data collected by ECPD show that about three quarters of the graduates of technology programs have been offered positions with the word "engineer" in the title. Some examples are junior engineer, engineer trainee, sales engineer, customer engineer, maintenance engineer and manufacturing engineer. Essentially the same titles are used by industry for engineering technology graduates as for engineering graduates in beginning jobs.

> An examination of the titles of industrial positions offered hundreds of baccalaureate graduates did not disclose a single title using

> the word technologist or technician although these titles do appear in descriptions of certain civil service positions (ASEE, 1972, p. 29).

The following are additional examples of the confusion that exists in the minds of engineering and technology faculty as well as in the world of engineering practice:

1. Policy thirteen of the Engineers Council for Professional Development (ECPD) Objectives and procedures for Accrediting Programs in Engineering Technology states: "The Engineering Technology Committee will not recommend for accreditation as a curriculum in engineering technology any curriculum for which the claim is made that it produces engineers."

2. The Institute of Electrical and Electronic Engineers (IEEE) will now accept baccalaureate candidates of both engineering and engineering technology curricula into their first membership grade, and they have also established a membership grade for associate degree graduates in engineering technology.

3. Several states, for example, Illinois and South Carolina, have specifically excluded the possibility of four year engineering technology graduates from becoming registered professional engineers. However, many Engineering Technology graduates have been registered in other states.

4. The U.S. Civil Service Commission recently eliminated the possibility of Technology graduates being classified as an engineer in the Civil Service hierarchy although there has been no evidence that current technology graduates employed by the government are performing below the level of their engineering counterparts (Thomas, 1976).

5. The U.S. Department of Commerce Bureau of the Census report on the Survey of Professional, Technical and Scientific Manpower in 1972 shows that 1,242,519 people were classified in the civilian work force as engineers. The educational attainment of working engineers in 1972 shows that 38.3 percent had no bachelor's degree, 45.9 percent had a bachelor's degree and 15.7 percent had graduate degrees. A 1970 report indicates that of those engineers who were baccalaureate graduates, only 76 percent had their highest degree in engineering (NSF, 1972).

Statement of the Problem

Since World War II, engineering curricula have moved toward an emphasis upon the science of engineering with less attention to the practical application of engineering principles. Philosophically at least, most engineering schools have accepted the ideal that the Master's degree should be the minimum attainment for entry level to the "Profession" of engineering. As a result, the undergraduate

curriculum has been planned with the assumption that students will continue their education into graduate school. Many students however, expect to seek employment after graduation with a Bachelor's degree. Industry has by no means accepted the viewpoint that a Master's degree is required for a majority of their positions. The maximum number of positions in research, development and design for which the science oriented curriculum is designed, even in a high technology company such as General Electric, is estimated to be approximately 50 percent of the total (Irwin, 1974, p. 32).

Since there are many positions in the engineering spectrum that require various levels of talent and education, a real question arises: "Should the majority of students, aspiring to a technical career in general, be exposed to a curriculum designed for advanced positions in research, development and design?" The answer, logically, should depend upon the level of the majority of positions and the qualifications required to perform in these positions.

For this study, it was hypothesized that the philosophy of engineering technology education, with its reduced emphasis upon mathematics and its orientation to practice and application, might be more appropriate for individuals that are to be trained for many positions now classified as engineering rather than technology. To test the hypothesis, it was proposed that electrical engineering graduates of the University of Alabama, currently employed in industry, would be questioned relative to their

utilization of and need for subject matter contained in the Electrical Engineering and the Electrical Engineering Technology curricula. Mathematics was chosen as the principal indicator since it is the characteristic most prominent in distinguishing the two types of programs.

The study was intended to provide significant data for answering the following specific question: Is the practice of Electrical Engineering, by a majority of practitioners, closer to that envisioned by the Electrical Engineering or by the Electrical Engineering Technology curriculum?

It was expected that data might also be provided for answering the following additional questions:

1. Is there justification for the two closely related but separate programs? Should either program be eliminated or should the programs merge?

2. Should emphasis upon mathematics and practice-oriented subjects be altered for either program? Should the curriculum for Engineering move toward Engineering Technology or vice versa? Should the programs converge or diverge?

3. Should Engineering Technology graduates be permitted to register as Professional Engineers? If practitioners who have received registration are found to be doing "technologist" work, then should this fact influence the eligibility of technology graduates to seek registration?

4. In what ways should counseling of prospective students for each type program be modified.

Significance of the Problem

For many years, electrical engineering has been the most theoretical or mathematical of engineering curricula (ASEE, 1972, p. 33). Electrical Engineering is also a field that has undergone great change in its representative technology. For example, the specialty of electronics, once centered around vacuum tubes and radios, has evolved into solid state and semi-conductor circuits with applications in computers, adaptive control, entertainment, medicine, etc. Large scale integration techniques have allowed the development of a technology permitting thousands of individual transistors to be fabricated into circuits occupying a volume formerly required for a single component. Electrical engineering now embraces a set of software techniques that are as extensive as those for hardware. Application and system design are replacing circuit design for a majority of engineers involved in user oriented equipment and major portions of engineering calculations are accomplished using electronic calculators. Fewer engineers are involved in basic design but there is increased emphasis upon application of basic designs at a systems level (Lapidius, 1974).

While the engineering curricula have shifted toward an emphasis upon mathematics and science, the practice of

engineering, for a majority of practitioners, has been moving toward greater dependence upon application. A major conclusion of a recent Massachusetts Institute of Technology commissioned report (1975, p. 42) was that "We must move to reintroduce the art of engineering into engineering education."

Courses for the technology programs at the University of Alabama, begun in 1972, have been developed as the need arose and there has been a gradual evolution and growth. Validation of objectives and acceptance of graduates are necessary conditions for achieving permanence and future growth. Results of this project may contribute to achieving these conditions.

Engineering programs at the University of Alabama are also in transition. They are currently being examined in an effort to find ways to achieve a balance between preparation for practice while maintaining a strong base in fundamentals. Addition of a visiting lecturer program last year is an example of such efforts to reintroduce practice orientation. This study may also contribute to these programs since current information of the type obtained from graduates has not previously been available. While specifically related to programs at the University of Alabama and its graduates, there can be implications for other institutions. There is considerable interest at a national level in future directions for engineering education.

Rationale for Study

The characteristic most prominent in distinguishing Engineering from Engineering Technology is the level of mathematics required for entry, the subsequent emphasis upon mathematics in required courses, and in the application of the techniques of mathematics to the technical specialty. The following statement by ECPD in their accreditation criteria for programs in Engineering Technology reflects this philosophy.

> Basic Science and Mathematics--College Algebra is the beginning point for both the associate and baccalaureate degree programs in technology (whereas mathematics for the engineering programs begin with calculus). This significant difference is reflected throughout the required basic sciences, technical sciences, and technical specialty sequences. The allocations within this group would depend partly upon the specific technology area--for example electronics technology might need a higher percentage of the total, whereas a program in construction technology might satisfactorily be served by the minimum. Trigonometry and selected topics in analytic geometry and calculus should round out the minimum mathematics requirement. Other subjects in mathematics, statistics or computers may be included when needed to strengthen the foundation for subsequent technical subjects. Remedial courses in mathematics or non-laboratory courses in the sciences are not to be used to meet this definition and required minimum (ECPD, 1973).

Thus, the study was planned so as to concentrate upon securing data that are primarily concerned with mathematics utilization by graduate engineers. Acquisition of these data involved preparation and submission of questionnaires.

The sample selected to receive the mail questionnaire was comprised of graduates of the University of Alabama from 1950 through 1974 who had received a Bachelor of Science in Electrical Engineering degree. (It was not possible to survey Engineering Technology graduates since there are none at this time). Selection of this sample for the survey was believed to have several advantages:

1. Clientele to be served in the future should have many characteristics in common with those served in the past.

2. The range of experience to be encountered should provide data on a good cross section of duties and responsibilities.

3. A willingness to cooperate in the survey could reasonably be expected.

Limitations

1. The sample for the project was derived from a list of graduates in Electrical Engineering of the University of Alabama at Tuscaloosa, Alabama. There have been no graduates in Electrical Engineering Technology. Thus, no comparison of respective responses was possible.

2. Communication with participants was by mail. Questionnaires were mailed to graduates for whom a mailing address was believed to be current. Additionally, since mailing was done under a bulk mailing permit, some members

of the sample may not have had the test instrument delivered to them.

3. The population selected for sampling did not include self trained practitioners or persons whose primary education was in a field other than Electrical Engineering.

4. Many recipients of the questionnaires were found not to be currently employed as practitioners.

5. Questionnaire responses are subjective and could have been influenced by educational experiences rather than by the reality representing actual practice.

6. The results have only general implications for programs other than Electrical Engineering Technology and Electrical Engineering.

7. The study does not attempt to evaluate the role that study of mathematics may play in orienting or disciplining a student toward an "Engineering" attitude or viewpoint.

8. Electrical Engineering is a field that changes rapidly. Existing or past utilization of proficiences may not represent requirements of the future.

Definition of Terms

The following terms are included as applicable to this study:

1. Accredited--program having met the criteria for accreditation of the Engineer's Council for Professional Development (ECPD).

2. ECPD--Engineer's Council for Professional Development.

3. Engineer-in-Training--an individual who has complied with the requirements of a state board of engineering registration to receive this designation and who has not yet met the requirements for full registration as a Professional Engineer. Sometimes referred to as Engineer-Intern.

4. Engineering--the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind (ECPD definition).

5. Engineering Technology--that part of the technological field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer (ECPD definition).

6. Graduate Engineer--graduate of a four year ECPD accredited engineering program.

7. Industry--includes all the users of the graduates of engineering and engineering technology programs such as manufacturing firms, government agencies,

consulting firms, service organizations, etcetera, but excluding education.

8. Practitioner--one who is gainfully employed in the practice of engineering.

9. Professional Engineer--a person duly registered under the terms of State engineering registration statutes.

10. Technician--graduate of a two year program in Engineering Technology.

11. Technologist--graduate of a four year program in Engineering Technology.

Chapter II

REVIEW OF RELATED LITERATURE

Studies that have had significant impact upon technical education and particularly relevant to this project have predominantly originated with the American Society for Engineering Education (ASEE). ASEE is essentially an educator's society, although it does encourage industrial membership. However, members from industry have generally found it difficult to become effectively integrated (Dwon, 1975). ASEE was originally organized in 1893 as the Society for Promotion of Engineering Education. Throughout its history ASEE has continued to encourage or initiate studies having objectives of keeping the engineering educational process up to date. As Dr. Eric Walker wrote in 1971, "Engineering education has been studied more by its practitioners than any other type of education including medicine." Major studies that have had large influence upon technical education, and their relationship to the present study, are highlighted as follows.

MAJOR STUDIES

The Wickenden Report

"A Report of the Investigation of Engineering Education," was a major study extending over the years 1923-29 conducted under the chairmanship of W. E. Wickenden. The Wickenden report, funded by the Carnegie Corporation is the largest and most comprehensive study ever done on the subject of engineering education, having more than 1,600 pages in two volumes on both engineering schools and technical institutes. It is the only study ever to have extensively compared engineering education in the United States and Europe. The Wickenden report is generally given credit for the establishment of the Engineers' Council for Professional Development (ECPD), now the recognized agency for accreditation of engineering and technology programs in the United States. From its massive contents one statement is often cited. "The most serious deficiency in engineering education is not so much in matter taught or matter omitted in colleges as in allowing the orderly process of education to stop where it so often does, at graduation" (Dwon, 1975). This statement has particular significance for its relationship to a major argument for the present day science and math oriented curricula--that of avoiding obsolescence. The implication was that obsolescence is not nearly so much a result of whether or not undergraduate curricula

emphasize math and science but whether or not one continues to study over his life span.

The Hammond Report

Subsequent major reports were prepared by H. P. Hammond. "Aims and Scope of Engineering Curricula" (1940), "Present Status and Trends of Engineering Education" (1940), and "Engineering Education After the War" (1944). These reports referred to scientific-technological and humanistic stems for engineering curricula and recommended a four-year norm for the undergraduate curricula. They also urged flexibility and diversity, not necessarily to be found in standardized curricula. Hammond (1944) indicated that engineering programs in universities should be heavily "hardware" oriented. The needs of post World War II were then thought to be for automobiles, refrigerators, washing machines, highways, bridges, building, etc., that required the application of known engineering principles. This need as seen by Hammond, is not unrelated to the current day philosophy forming the foundation for Engineering Technology education i.e. application of known engineering principles.

The Grinter Report

World War II had produced a massive increase in technological information and many engineers had experienced difficulty in adapting to major new technology which had

its base in relatively sophisticated math and science. The so-called Grinter Report, the first post war study of the system of engineering education, recommended some basic changes in the undergraduate degree programs. The "Report on Evaluation of Engineering Education" (1952-55) introduced the concept "That scientifically oriented engineering curricula are essential to achieve..." "...the development of men who can face new and difficult engineering situations with imagination."

L. E. Grinter's committee had made a preliminary report in 1953 with two important recommendations, along with others, for study by the engineering schools. They were (1) that the accreditation of engineering schools be based upon either of two defined functions in engineering education, i.e., professional-general education and professional-scientific education and (2) that a special designation be given to any curriculum taught by a faculty of unusual distinction where the program conducted by the faculty was of such nature as to develop in a considerable proportion of the graduates a capacity for creative technical activity or creative leadership in engineering. The committee expressed serious concern over the thought to be obvious need for a strong science background by a considerable fraction of engineers. Their concern was based upon a strong belief that such emphasis might have the effect of reducing student interest in the study of engineering. Accordingly, they had suggested a two-track curricular

concept, one track being more general or practice oriented and the other more science oriented.

After considerable study and comment the engineering schools, with near unanimity, rejected these recommendations for the two tracks and moved toward what may now be interpreted to be the professional-scientific program. It was here that a major void began to be created resulting in what often appears to be a major disparity between the requirements of engineering practice and the engineering curricula. In retrospect many engineering technology proponents believe that the four-year technology programs are evolving to fill the void created when the professional-general or practice oriented curriculum was ignored in the 1950's (Dwon, 1976). The final Grinter report issued in 1955 left little doubt of a belief that the future of engineering education would depend upon its substituting a foundation of physical science and mathematics for the "art" of engineering. As a result of the final Grinter report, engineering programs throughout the United States were substantially revised. This revision included the designation of college algebra and analytical geometry as pre-college courses. The beginning math course for engineers in universities was and is calculus. The revised curricula also recommended courses for new scientific advances, courses covering newly developed materials and courses stressing engineering analysis. The

Grinter Report curriculum deleted some of the "skill" courses from the typical engineering program such as drafting, machine shop, forging, welding, surveying, etcetera.

The Goals of Engineering Education

This study, funded by the National Science Foundation at a cost of over three-hundred thousand dollars, with Dr. Eric Walker as chairman, was the next major study conducted by ASEE. Beginning in 1961 with its final report in 1968, it supported the trend of the 50's toward science and math and advocated Engineering as a "Liberal Science" program. Integration of the computer as a basic tool was recommended. Renewed emphasis upon the humanities and social studies was suggested. It was urged that the curriculum should include courses in communication skills, synthesis, analysis and design of systems, experimental engineering and laboratory work, engineering ethics and professional attitudes. Recognizing the limitations inherent to a four year curriculum, a major proposal was made that there should be growing recognition that the Master's degree should become the basic professional degree in engineering.

This proposal for the Master's degree has not been generally accepted by industry or by students. However, many educators feel that this step must be taken if engineering is to become a true profession (Thomas 1976). As a result of the accepted necessity for an additional

year or more of study there resulted even more deletion of practice and design oriented courses from the four year curriculum than was originally envisioned by the 1955 Grinter report.

Engineering Technology Education Study

The next major study of interest to this project was the "Engineering Technology Education Study" again conducted by ASEE, funded by the National Science Foundation, and chaired by Linton E. Grinter. The study was formally initiated in August 1969 with its final report dated January 1972. The report repeatedly emphasized that the engineering technology programs and its graduates should not duplicate or emulate those for engineering. Engineering Technology was defined as being concerned primarily with the application of established scientific and engineering knowledge and methods. Although mathematics should be taught at the college level, it should emphasize problem solving rather than derivation and proof. "Enough calculus should be taught to guarantee that students are professionally literate and to permit use of this mathematical tool in the technical specialties." The Grinter report of 1955 had indicated that future engineering curricula should show a decrease in the time devoted to technical skills, for example, drafting and manufacturing processes. The technology curriculum was expected to move in to fill the void.

Other Literature

The cited studies or reports have had major impact upon the revision and progress of engineering education. However, the past few years have seen complaints from some segments of industry and from practitioners that engineering curricula have moved too far in favor of math-science at the expense of practice oriented courses. The 1955 Grinter report stirred up a hornet's nest when it was published as did the "Goals" report. Some critics of the 1955 report feared that American engineering schools would be turned into second class science departments. Critics of the "Goals" report worried that a stampede to graduate school might be caused, perhaps downgrading the master's degree. It was also feared that professional recognition might be denied to those who could not qualify for graduate school (Kemper 1967, p. 228).

Dr. J. B. Wilbur (1955) wrote,

> The point which seems to have been overlooked is that, since science deals in the main with systemized knowledge, an increasing emphasis on science, and on a wholly rational approach to things, steeps the mind of the student in the processes of exact reasoning, to the partial exclusion, and perhaps to the inhibition of judgment, imagination and intuition. Yet, these are essential to successful work in the broader spheres that include, but lie in part beyond the limits of systemized knowledge...

Philip Sporn (1956) agreed,

> ...in engineering we are in grave danger of going too far in making false gods of mathematics and physical science and giving them too much emphasis as we seek solutions to the problems of combining resources, tools and energy to advance the welfare of man.

Dr. C. J. Freund (1960) stated it somewhat differently. "If educators don't produce more artist engineers, the nation will end up with a population of brilliant scientists, and libraries full of research reports, but nobody who can put these reports to use."

A Massachusetts Institute of Technology Committee on Engineering Design reported in 1961.

> Recent engineering graduates were criticized for unwillingness and inability to consider a complete problem such as a design problem. Instead they showed a desire to seek a fully specified problem which could be answered by analytical methods. It was stated that engineers with advanced degrees were even more prone to avoid a complete problem... In short, young engineers feel at home in solving problems having numerical answers--the kind of problem used in school for teaching analytical techniques.

The committee also commented that many engineers seem to believe that any problems not requiring higher mathematics are beneath their dignity and so, let them pass to technicians. "This attitude," said the committee, "often prevails in spite of the clear indication that the most important decisions in a design problem must often be made without the assistance of higher mathematics."

A study by Dr. Samuel Dubin and associates at Penn State (1963) of activities engaged in by practitioners of engineering in Pennsylvania, concluded that engineers spent an average of at least 66 percent of their time performing in activities which were primarily administrative.

John Kemper, (1967) in his book "The Engineer and His Profession" had this to say about engineers and mathematics.

> Two types of engineering graduates with serious misconceptions about the role of mathematics in engineering regularly emerge from school. The first is the undermathematizer, who cannot wait to get out of school so that he can forget about calculus and differential equations. The other is the overmathematizer, who is so deeply impressed by the power of mathematics in physical problems that he thinks mathematics is physics. The existence of the undermathematizer is easily accounted for: he has been talking to practicing engineers in industry who have assured him that calculus is useless--after all, they never use it. The creation of the overmathematizer is a more subtle process and comes about through basic misconceptions concerning the nature of mathematics (Kemper, 1967 p. 170).

Caroline Bird, stating "The Case Against College" (1975, p. 97) presented her own pragmatic viewpoint.

> 1) Students in professional schools learn a lot of things they never use; 2) Professional workers have to learn a lot of things that are never taught in schools; and 3) Most of what professional schools teach is likely to "come in handy later" than it is to fade from memory and relevance....Professionals on their first jobs complain that their education isn't used at all. Employers demand a degree in engineering or science and then put the graduate to work at jobs that would not tax a mathematically inclined high-school student. Manpower specialists say that this talent stockpiling creates an artificial "shortage" of scientists and engineers.

At a recent American Society of Civil Engineers conference the subject of what was wrong with today's engineering education was discussed. Dallaire (1974) quotes a participant, William Moore, as follows:

> There has been a divergence between engineering education and practice for at least two decades. This divergence is disastrous, crippling the ability of the profession to serve society. Behind the shift from practice oriented to research oriented schools is: a post Sputnik emphasis on physical sciences and mathematics, availability of federal research dollars, and hiring research-oriented PhD faculties with no practical experience. A major part of the problem is the professor himself. He spends four years as an undergraduate, or four more years as a graduate student, concentrating on research. He is then turned loose in the classroom, where he regurgitates what he has been taught by an earlier version of himself--or he may expound on his thesis. It is somewhat like expecting a eunuch to teach a class in sex education....

Stephen R. Clark, in a paper delivered at an ASEE conference early in 1976, described technical employment at the Caterpillar Tractor Company.

> In our company there are four areas... there is a very real requirement in each of these functions for creativity, for new concepts in design, and for theoretical calculations prior to experimental development. There are also problems to solve by applying conventional and practical combinations. I estimate that from 50 to 70 percent of the engineers in these departments will seldom utilize the theory-oriented aspects of their engineering knowledge....In most of the other functions in which we hire engineers, the work will seldom if ever, require the use of calculus, thermodynamics, or theory of equations. Engineering graduates hired into plant operations, purchasing, quality control, market development, and data processing have shown greater interest in application work than in theory....Actually we are not utilizing the four year technology graduates in support of engineers... Instead, the technologists are working in practical application areas.

Irwin (1974, p. 28) in discussing the work and responsibilities of engineers and technologists, stated:

> Let us not delude ourselves that engineers make many weighty decisions based solely upon technical knowledge. There are many business decisions, economic decisions, political decisions, social decisions--all of which may have an engineering input. Final decisions are an integration of all these decisions, usually dominated by factors other than technical.

Summary

There have been drastic changes in the philosophy of engineering education since World War II. Many changes have been appropriate and necessary as a result of the rapid expansion of technology. However, there has also appeared to be a major discrepancy between the preparation given a prospective engineer and the requirements for the majority of industrial positions. The studies impacting educational practice and accreditation criteria have reflected opinions of educators with little encouragement given to inputs from industry. Recent overtures from IEEE, the major engineering society for Electrical Engineers, for increased participation in the ECPD accreditation process, were denied (Feerst 1976).

Thus, the project which is the subject of this report--whereby information, having potential for influencing curriculum revision, was acquired from alumni--may be unique. This attempt, although of limited proportions, may provide considerable insight into defining the spectrum of activities and proficiencies encountered

among practitioners in industry. The Engineering Technology programs at the University of Alabama, and the involved faculty, are not presently committed to established tradition. Thus, curriculum revisions will have the opportunity to be influenced by documented information as well as personal convictions characteristic of the cited literature.

Chapter III

METHOD OF PROCEDURE

Preliminary Steps

The proposed investigation was discussed with associates and with appropriate Department and College administrative personnel of the University of Alabama. Agreement as to intent and approval to proceed were secured from the office of the Dean of the College of Engineering. This office made available a list of all graduates in Electrical Engineering along with mailing addresses and other statistics. Access to related data bank and computer processing facilities was provided and approval was given for mailing of questionnaires under the name of the University and its third class mailing permit. The project was to proceed with full approval of the institution but without funding or formal sponsorship.

Design of Questionnaire

The survey instrument sent to each graduate was designed to assess the occupational status and the level of experience of each respondent as well as the attitudes each held for various activities or subjects involved in

their employment. Emphasis in this study was placed upon the various topics in mathematics included in the curricula of the Electrical Engineering and Electrical Engineering Technology programs at the University of Alabama. Other aspects of the curricula, such as engineering graphics, technical writing and presentations or public speaking were included. Substantive course work unique to the technical specialty was not included. Some guidance was received in the preliminary stages of questionnaire development by reference to earlier studies that were somewhat similar, although with different emphasis, conducted by Dr. Samuel Dubin (1963) and Lebold, Perrucci, and Howland (1966).

A report prepared for the Massachusetts Institute of Technology had stated, "Graduate engineers who stay in engineering are apt to be unhappy in their work according to scanty formal evidence available" (MIT, 1973, p. 41). This apparent dissatisfaction has often, without evidence, been referred to as a major influence in the, until recent, decline in engineering enrollments (Walker, 1976). Two questions intended to be indicators of this dissatisfaction were included in the general background portion of the instrument. It was anticipated that a relationship might be disclosed between subject use frequency and dissatisfaction.

General design of the questionnaire was divided into six sections in accordance with the following format.

1. Part 1 of this study solicited general information regarding the respondents education, salary level, years of engineering experience, type of business, etc. Such information was desired to characterize the respondent, to establish his practitioner status and for use in evaluating further data.

2. Part 2 pertains to the amount of work time allocated to various functions such as design, research, production, etc.

3. Part 3 further classifies the respondents use of time in various activities, such as conferences, correspondence, estimating, field work, presentations, etc. This part is particularly important since it indicates what portion of the engineers time is actually available for utilization of his mathematics knowledge or proficiency.

4. Part 4 provides indication of the extent to which various subjects or proficiencies, for example, algebra, calculus, technical writing, etc., have been utilized during the past year by the respondents.

5. Part 5 is similar to Part 4 but the time frame has been extended to include the respondents' entire career. These two parts allow for assessment of any major difference that might exist between a respondents current assignment and the broader experience of his entire career.

6. Part 6, the most complex portion of the questionnaire with its seven sub-sections, asks for

an expression of attitude held for the importance of the various subjects to such considerations as the job itself, future performance, the engineering curriculum, and continuing education.

Pilot Survey

A pilot design of the survey instrument was prepared and submitted to a limited group for their response and comment. Original recipients consisted of five educators and five electrical engineers. This group was selected because of time limitations and since they were known to be interested in the general intent of the survey. As a result, cooperation was assured and turn-around time minimized. Several ambiguities were detected in the instrument and unanimous agreement was expressed on the necessity to revise the format of Parts 2, 3, and 6.

Survey

The revised questionnaire (see Appendix A) was mailed to prospective respondents selected from the list of graduates shown to have received a Bachelor's degree in Electrical Engineering in the years 1950 through 1974. Names of individuals known to be non-practitioners were eliminated. Five hundred and thirty one questionnaires were posted during the first week of February 1976. The mailing was accomplished in two parts. A first group of one hundred questionnaires was sent by first class mail and the remainder was posted under the third class bulk

mailing permit. All questionnaires were accompanied by a stamped and pre-addressed return envelope. The return envelopes of questionnaires mailed by first class were given an identifying mark. (a small dot.) This procedure was used so as to obtain some indication of the relative efficiency of the two methods of handling. It was not then known what rate of return might be expected and it was considered that any follow up re-mailing should receive the most effective handling.

By February 12, 1976 the first replies were received and a steady daily stream began with a peak of fourteen replies for one day. By March 12, 1976 the number of replies had dwindled to approximately three per day. A total of 174 responses had been received and a decision was made that this should be the cut-off point so that computer batch processing of the received data might be initiated. In addition to the 174 questionnaires, three empty envelopes were returned and two notes were received stating that the questionnaire was not applicable to the writers since they had never worked in engineering. Several unsolicited notes were received containing criticisms, questions, and additional information to expand upon their questionnaire response.

The rate of return was thirty two percent as of the cut-off date. Returns from the first class mailing were approximately thirty percent while for the third class mailing returns were approximately thirty three percent. However, most of the first class mail responses were received

during the first two weeks of activity.

Analysis

Returned questionnaires were examined daily to gain insight into the pattern of response. However, the magnitude of data involved allowed only general and qualitative observations to be made by such manual means. Resources of the University of Alabama Testing Service had been made available to this project and transfer of data to punched cards for computer batch processing began on March 17, 1976. The punched card data were later transferred to magnetic tape for storage. Handling and processing of questionnaire data were done on a time available basis inasmuch as funded programs commanded priority attention.

Each questionnaire returned was given an individual identity and its contained responses were thus categorized. The individual identity allowed comparisons within given questionnaires as well as with other questionnaires. The number of responses, the mean response and standard deviations were of primary interest for most categories of questions. No variables were manipulated during the study although it was determined that certain aspects of the background data on each respondent would be considered as independent variables to allow various comparisons with other data.

Results of the various tabulations and comparisons were organized to conform to the questionnaire format

already described. Summary, i.e. mean, responses were entered into individual pages of the questionnaire form to facilitate display and understanding of the survey results. A number of additional tables were prepared to allow display of derived information. Presentation and discussion of results are to be found in the major chapter that follows.

CHAPTER IV

RESULTS

Presentation of results follows the format of the submitted questionnaire, shown in Appendix A. Also, individual pages of the questionnaire form, as though completed by a "mean" respondent, have been utilized as a method of presentation whereby recording and understanding of results may be facilitated. The statistics presented are primarily descriptive. No variables were manipulated. However, the demographic data from Part 1 of the questionnaire were considered to be independent variables for comparisons with subject use frequency which became the dependent variable. Statistics displayed in graphic or tabular form are presented immediately following the written discussion.

GENERAL BACKGROUND

The data from Part 1 of the questionnaire characterize the respondents and are used in conjunction with evaluation of other data. Responses have been entered into the questionnaire form as a percentage of total responses and displayed as Table 1. Also, information relative to respondents' experience, industry affiliation and income level has been further portrayed in Figures 1, 2, and 3 respectively.

Eighty seven percent of the respondents indicated that a Bachelor's degree was the highest degree held. This information helps to establish that further data are appropriate to a study and conclusions involving Engineering Technology. A Bachelor's degree in Technology is currently considered a terminal degree rather than a prelude to graduate school.

Thirty two percent of the respondents are not now employed in positions classified as engineering positions. Thirty three percent would not choose the study of Electrical Engineering if given another opportunity, and thirty percent would not recommend its study to a young person. These data were requested as indicators of career satisfaction.

Figure 1 presents the range of engineering experience reported by respondents and establishes practitioner status even though the respondent may not now be employed in an engineering position. Responses secured from graduates showed a reasonably uniform distribution of experience with a slight peak in the eleven to fifteen years of experience category.

Thirty eight percent of the respondents indicated status as an individual worker with another fifty percent divided equally between the categories of supervisor and mid-manager. Seventy one percent of the respondents stated that their position involved supervision. Many of the individual workers, although not classified as supervisor,

still claimed supervisory responsibility.

Figure 2 illustrates the distribution of respondents in various industries likely to employ graduates. A significantly higher proportion of graduates reported employment in the three industries classified as Government, Military/Defense, and Power Utility. Employment was reported to be fifty percent greater in the Power Utility category as in the next highest category of Military/Defense. A category termed "other" disclosed employment in such fields as aviation, chemicals, insurance, maintenance, mining and petroleum. The significant response from the Power Utility field may have implications for curricular inclusions such as courses in energy conversion, nuclear instrumentation or other offerings ordinarily considered as specialized electives.

Figure 3 portrays income distribution reported by respondents. Income was reported in all ranges with responses peaking in the twenty to twenty five thousand bracket. There was one response in the five to ten thousand range and three from the fifty thousand plus category.

Twenty eight percent of the respondents reported status as a Professional Engineer and another nine percent indicated they were Engineers-in-Training. It is evident that a majority of graduates have not been motivated to take this step. Professional registration is seldom a requirement of the industrial environment.

Table 1. Percent of Respondents checking various Categories- Questionnaire Part I

GENERAL BACKGROUND

INSTRUCTIONS:

Please check the appropriate space for each of the items listed below.

1. Are you currently employed in a position classified as Electrical Engineering? Yes 68

2. How many years of engineering experience do you have?
1-3 14 4-6 13 7-10 19 11-15 22 16-20 16 21-25 10 25+ 5

3. What is the highest degree, in Engineering, earned by you?
BS 87 MS 12 Doctorate 1

4. In what type of Industry is your current employment?
Broadcasting 1.2 Communications Utility 6.9 Computers 3.5
Consumer Goods 2.9 Consulting 2.9 Construction Industry 2.3
Education 1.2 Electrical Apparatus 6.3 Electronic Components .6
Government 12 Military/Defense Industry 16 Power Utility 24
Semiconductor Mfg. 0 Transportation 3 Other (specify) 15

5. Are you a registered Professional Engineer? Yes 26 No ___
or Engineer-in-Training? Yes 9 No ___

6. Is your present position best described as: Individual Technical Worker 38 Supervisor 25 Mid Management 25 Upper Management 8.6

7. What is your approximate income per year from engineering employment or service? 5-10K .6 10,001-15K 7.5 15,001-20K 26 20,001-25K 35
25,001-30K 14 30,001-40K 11.5 40,001-50K 1.7 50K+ 1.7

8. If your position involves supervision, what is the number of employees supervised? 1-3 22 4-6 12 7-10 7 11-20 13 20+ 17

9. Assume that you might somehow have the opportunity to re-initiate your career. Based upon your own work experience would you still choose the study of Electrical Engineering? Yes 67 No ___

10. Would you recommend a career in Electrical Engineering to a young person preparing to enter college? Yes 70 No ___

11. Are you interested in receiving a report on the results of this survey? Yes 81 No ___

[a]Total percent response may not add to 100 percent due to round-off or as a result of some respondents not answering all questions.

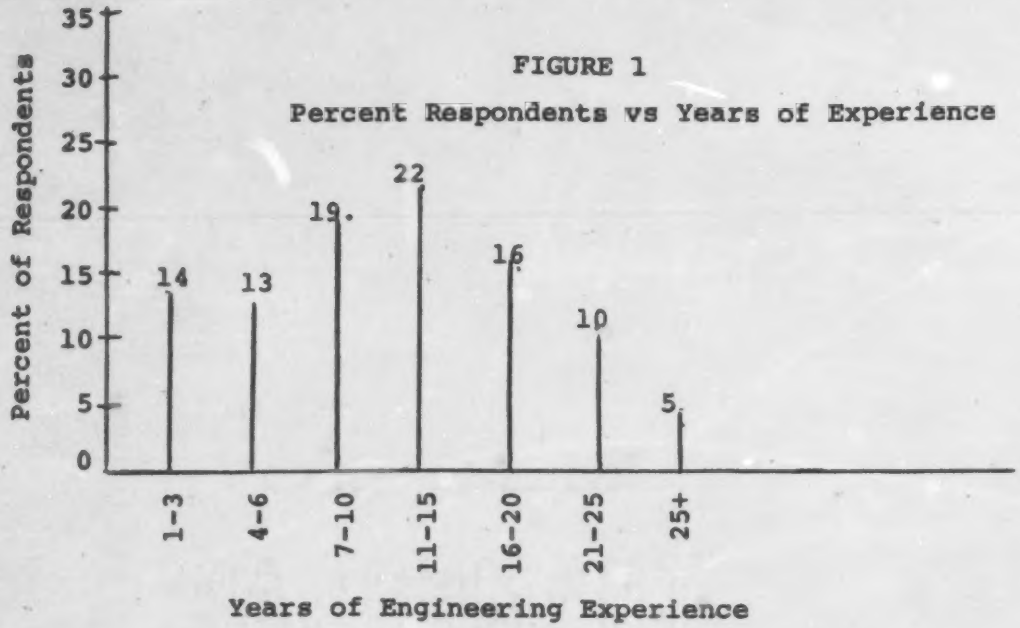

FIGURE 1

Percent Respondents vs Years of Experience

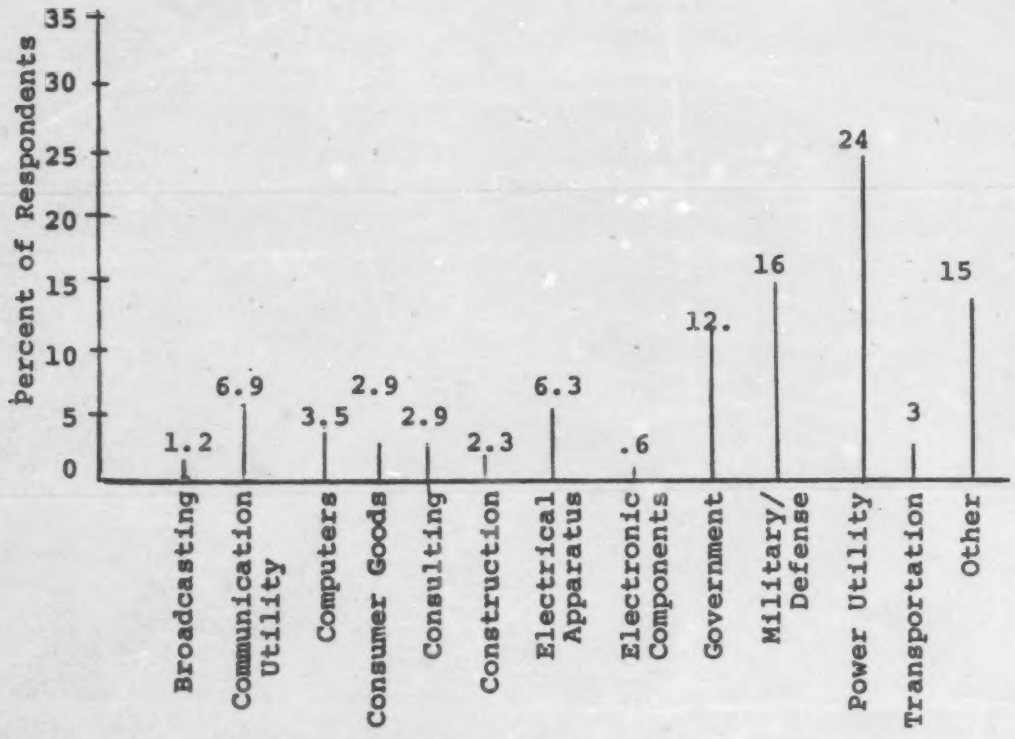

FIGURE 2

Percent Respondents vs. Industry Affiliation.

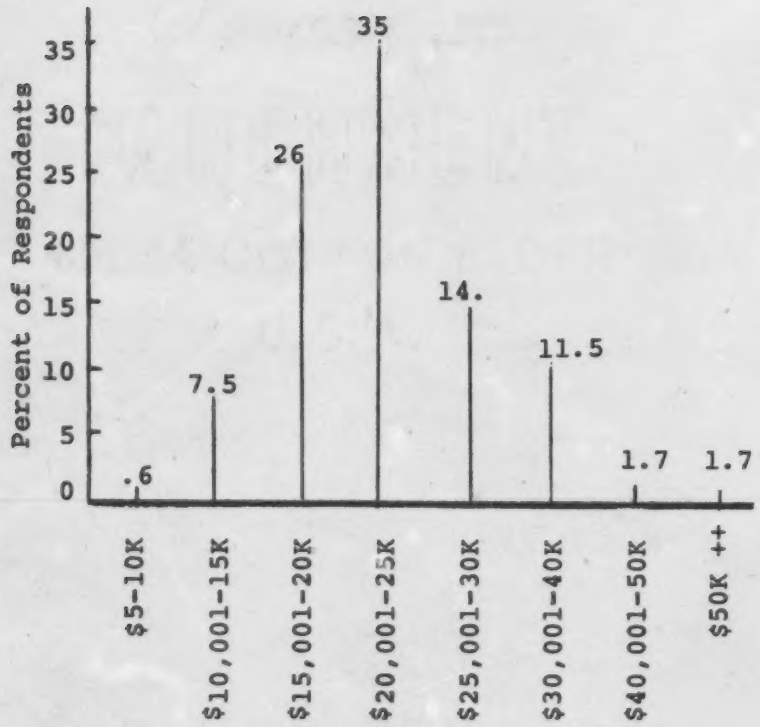

FIGURE 3.

Percent of Respondents vs. Reported Income

FUNCTIONS

Part 2 of the questionnaire requested recipients to estimate the amount of time that they spent during an average work week in performing in various functions. The results indicate that the range of functions performed by engineers is quite varied. Not all respondents reported time in every function listed. The mean value of the responses obtained has been calculated and entered into the questionnaire form as shown by Table 2. More significantly, however, the data have been further organized and the functions ranked by number of participants reporting some time in the function. Table 3 shows the functions in order of rank along with the number of respondents reporting time spent and a distribution of respondents in terms of percent of time spent in the function.

A large number of respondents reported time spent in functions not ordinarily considered technical and that are not typically taught in the technical programs. Planning, Administration, Consulting, Management and Estimating occupy the first five ranks. The number of respondents reporting time spent and the frequency of occurrence may have implications for future curriculum and course development. Although many engineers may aspire to management positions, they have not typically been prepared by virtue of their undergraduate education.

Table 2. Mean Response[a]- Questionnaire Part II

FUNCTIONS

INSTRUCTIONS:

Please estimate the approximate time, as a percentage of your total working time, which you spend, during an average work week performing the following functions. It is realized that the total of these estimates may not add up to exactly 100 percent.

Administration	17 %
Construction	9 %
Consulting	8 %
Design	22 %
Development	11 %
Estimating	7 %
Maintenance	12 %
Management-Nontechnical	19 %
Management-Technical	27 %
Operations and/or Production	18 %
Planning	11 %
Quality Control	7 %
Research--Applied	4 %
Research--Basic	2 %
Sales--Applications Engineering	17 %
Testing	14 %
Other (please specify _____	20 %

[a]Response recorded is the mean for those reporting time in the function. All respondents did not report time in every function.

Table 3

A Comparison of Functions Required of Respondents, Number (N) Reporting Time Spent in the Function and the Amount of Time Reported. Functions are Ranked by Number of Respondents Reporting Time Spent in the Function

Rank	Function	Total N	N Distribution by Percentage of Time Spent									
			1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
1	Planning	131	95	28	4	3	0	0	1	0	0	0
2	Administration	130	61	36	13	12	4	1	3	0	0	0
3	Consulting	101	80	[illegible]	6	0	0	0	0	0	1	0
4	Management (Technical)	94	51	19	8	5	4	2	1	3	1	0
5.	Estimating	90	82	7	0	0	1	0	0	0	0	0
6	Design	89	49	18	5	2	6	3	2	2	2	0
7	Management (Non-Technical)	73	45	11	5	5	6	0	1	0	0	0
8	Development	72	44	18	5	4	1	0	0	0	0	0
9	Operations-Production	53	31	12	2	1	5	0	1	1	0	0
10	Maintenance	52	35	6	1	2	4	1	0	0	3	0
11	Testing	42	33	5	1	0	1	1	0	0	1	0
12	Quality Control	34	33	1	0	0	0	0	0	0	0	0
13	Construction	32	27	3	0	1	1	0	0	0	0	0
14	Sales-Application	26	14	4	2	3	1	0	2	0	0	0
15	Research-Applied	25	20	5	0	0	0	0	0	0	0	0
16	Other	16	6	3	0	3	1	3	0	0	0	0
17	Research-Basic	15	33	1	0	0	0	0	0	0	0	0

ACTIVITIES

Part 3 of the questionnaire requested information similar to that of Part 2 but for activities rather than functions. Results have been analyzed and presented in a similar manner. Table 4 shows the mean response entered into the questionnaire form and Table 5 presents activities by rank along with the number of respondents reporting time in the activity and a distribution of respondents in terms of percent of time spent in the activity.

As with the results of Part 2, the data show that a high proportion of time is spent in activities that are normally not identified as engineering in nature. The seven activities ranking highest - conferences, planning, coordination, correspondence, consulting, presentations, and supervision - are primarily administrative in nature. Non-routine calculations, which should account for most of the time available for mathematics application, ranks eleventh in number of respondents reporting. A large majority - seventy of the seventy four reporting such activity - indicate that only a small percentage of their time is spent in this manner. It may also be noted that over one half of the returns indicated no time spent in non-routine calculations.

Table 4. Mean Response[a]- Questionnaire Part III

ACTIVITIES

INSTRUCTIONS:

Please estimate the approximate amount of time, as a percentage of your total time, which you spend, during an average work week in the following activities. It is realized that the total of these estimates may not add up to exactly 100 percent.

Conferences	14 %
Consulting	9 %
Coordination	9 %
Correspondence	12 %
Drafting	8 %
Estimating	10 %
Field Work	15 %
Laboratory Work	17 %
Nonroutine Calculation	4 %
Planning	11 %
Presentations	5 %
Research	3 %
Study	3 %
Supervision	23 %
Technical Writing	9 %
Other (please specify) _____	15 %

[a]Response recorded is the mean for those reporting time spent in the activity. All respondents did not report time in every activity.

Table 5

A Comparison of Activities in which Respondents Spent Time, the Number (N) Reporting Time Spent in the Activity and Amount of Time Reported. Functions are Ranked by Number of Respondents Reporting Time Spent in the Activity

Rank	Activity	Total N	N Distribution by Percentage of Time Spent									
			1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
1	Conferences	151	122	21	6	1	0	1	0	0	0	0
2	Planning	150	119	26	2	1	0	0	0	0	0	0
3	Coordination	137	94	29	8	2	0	3	0	0	1	0
4	Correspondence	136	117	15	2	0	2	0	0	0	0	0
5	Consulting	111	89	16	5	0	0	0	0	0	0	0
6	Presentations	110	102	8	0	0	0	0	0	0	0	0
7	Supervising	108	44	33	12	6	8	1	1	1	2	0
8	Study	104	95	6	2	1	0	0	0	0	0	0
9	Tech Writing	100	93	3	2	2	0	0	0	0	0	0
10	Estimating	88	80	6	2	0	0	0	0	0	0	0
11	Non-routine Calculations	74	70	2	1	1	0	0	0	0	0	0
12	Field Work	64	45	10	1	3	3	1	0	0	1	0
13	Drafting	50	47	1	2	0	0	0	0	0	0	0
14	Research	48	39	9	0	0	0	0	0	0	0	0
15	Lab Work	31	18	6	4	1	1	0	1	0	0	0
16	Other	18	8	5	0	2	1	2	0	0	0	0

SUBJECT UTILIZATION

The questions in Parts 4 and 5 of the survey instrument requested responses relative to the frequency of use for various subject areas such as Algebra, Analytic Geometry, Calculus, etc. in the respondents work duties during the past year and entire career respectively. Responses were recorded in five categories of "never", "seldom", "occasional", "frequent", and "extensive". These terms were considered to fall along a continuum of the assigned values with "never" the low value of one on the scale and "extensive" associated with the high value of five on the scale. Value of the mean response has been plotted for each item as shown in Tables 6 and 7. Values computed for the mean and standard deviation of response in each subject area are recorded in Table 8.

The mean response entered into Table 6 shows Algebra, Presentations/Public Speaking and Technical Writing falling into the frequency of use area identified as "occasional". Engineering Drawing/Graphics, Trigonometry, Probability/Statistics and Vector Analysis appear as "seldom" and all other subjects appear in the "never" range. The standard deviations (Table 8) have a maximum of approximately one allowing frequency indications to extend into the next higher area.

Table 7 is quite similar. However, the "occasional" category now includes Engineering Drawing/Graphics, Analytic Geometry, Calculus, Trigonometry, Probability/Statistics,

State Variables, Vector Analysis and Z Transforms are to be found in the "seldom" column.

The data from Parts 4 and 5 of the questionnaire have been used for extensive comparisons with the demographic data obtained from Part 1. Years of engineering experience, industry affiliation, Professional registration status, supervisory status, income level, and career satisfaction have all been utilized as categories to which reported subject utilization frequency might be compared. Results of such comparisons may be seen by examination of Tables 9 through 21. There is only small evidence of frequency variation in the above categories.

Subject utilization frequency from Tables 6 and 7 along with the above described comparisons all yield profiles approximating an Engineering Technology rather than Engineering curriculum. The data from the questionnaire depicted in Table 5 should also be considered when viewing the various comparisons. Assuming that respondents have been objective in providing requested data, it may be inferred that the term "frequent" implies less than ten percent of available work time. There is only one instance, in the comparison tables, where the category extensive appears as a mean response and two where frequent appears. Neither are considered to have statistical significance. The first was in the case of a respondent reporting income in the 5-10K income bracket and the second from a single respondent under the industry classification Electronic Components.

Table 6. Mean Response - Questionnaire Part IV

PAST YEAR

INSTRUCTIONS:

Please place a check mark in the block which best describes your use of the following subjects in the performance of your work duties during the past year.

	1 Never	2 Seldom	3 Occasional	4 Frequent	5 Extensive
Algebra			●		
Analytic Geometry	●				
Calculus	●				
Complex Variables	●				
Conformal Mapping	●				
Differential Equations	●				
Engineering Drawing/Graphics		●			
Fourier Series/Integrals	●				
Descriptive Geometry	●				
Hyperbolic Trigonometry	●				
Infinite Series	●				
Laplace Transforms	●				
Matrices & Determinants	●				
Maxwell's Equations	●				
Numerical Analysis	●				
Partial Differential Equations	●				
Plane Trigonometry		●			
Probability and Statistics		●			
Presentations/Public Speaking			●		
Technical Writing			●		
State Variables	●				
Vector Analysis		●			
Z Transforms	●				

Table 7. Mean Response - Questionnaire Part V

ENTIRE CARFER

INSTRUCTIONS:

Please place a check in the block which best describes your use of the following subjects in the performance of your work duties during your entire career.

	1 Never	2 Seldom	3 Occasional	4 Frequent	5 Extensive
Algebra			●		
Analytic Geometry		●			
Calculus		●			
Complex Variables	●				
Conformal Mapping	●				
Differential Equations	●				
Engineering Drawing/Graphics			●		
Fourier Series/Integrals	●				
Descriptive Geometry	●				
Hyperbolic Trigonometry	●				
Infinite Series	●				
Laplace Transforms	●				
Matrices & Determinants	●				
Maxwell's Equations	●				
Numerical Analysis	●				
Partial Differential Equations	●				
Plane Trigonometry		●			
Probability and Statistics		●			
Presentations/Public Speaking			●		
Technical Writing			●		
State Variables		●			
Vector Analysis		●			
Z Transforms		●			

Table 8

Tabulation of Mean and Standard Deviation
Subject Use Frequency
Questionnaire Parts IV & V

Subject	Past Year		Entire Career	
	Mean	Standard Deviation	Mean	Standard Deviation
Algebra	3.10	.992	3.37	1.002
Analytic Geometry	1.89	.952	2.25	.991
Calculus	1.95	1.035	2.42	1.089
Complex Variables	1.49	.863	1.77	1.132
Conformal Mapping	1.14	.600	1.24	.694
Differential Equations	1.57	.936	1.98	1.117
Engineering Drawing/Graphics	2.92	1.234	3.24	1.124
Fourier Series/Integrals	1.52	.849	1.67	.960
Descriptive Geometry	1.51	.815	1.84	.937
Hyperbolic Trigonometry	1.19	.571	1.33	.738
Infinite Series	1.28	.655	1.53	.862
Laplace Transforms	1.53	.998	1.78	1.110
Matrices and Determinants	1.59	.965	1.87	1.065
Maxwells Equations	1.25	.663	1.40	.773
Numerical Analysis	1.68	.981	1.83	1.096
Partial Differential Eqtns	1.29	.670	1.60	.850
Plane Trigonometry	2.52	1.133	2.86	1.113
Probability/Statistics	2.43	1.228	2.57	1.176
Presentations/Public Speaking	3.40	1.227	3.51	1.004
Technical Writing	3.29	1.145	3.47	1.026
State Variables	1.17	.617	1.24	.631
Vector Analysis	1.64	1.039	1.93	1.145
Z Transforms	1.18	.607	1.25	.654

Table 9

A Comparison of Subject Use Frequency during the Past Year and Respondents Years of Engineering Experience

Subject	Frequency[a]						
	1-3 Years	4-6 Years	7-10 Years	11-15 Years	16-20 Years	21-25 Years	25+ Yea
Algegra	2.83	3.23	3.06	3.08	3.29	3.17	3.3
Analytic Geometry	1.62	1.95	2.09	1.89	1.75	2.06	1.8
Calculus	1.83	1.91	2.00	1.92	2.14	1.89	2.0
Complex Variables	1.21	1.41	1.79	1.45	1.64	1.39	1.3
Conformal Mapping	1.12	1.18	1.27	1.05	1.14	1.06	1.1
Differential Equations	1.58	1.59	1.58	1.66	1.71	1.33	1.3
Engineering Drawing/Draphics	3.00	3.50	2.76	2.76	2.96	2.89	2.8
Fourier Series/Integrals	1.50	1.68	1.48	1.58	1.71	1.22	1.1
Descriptive Geometry	1.42	1.68	1.55	1.47	1.54	1.50	1.3
Hyperbolic Trigonometry	1.17	1.23	1.21	1.16	1.39	1.06	.8
Infinite Series	1.33	1.23	1.39	1.21	1.39	1.17	1.0
Laplace Transforms	1.50	1.50	1.67	1.47	1.93	1.11	1.1
Matrices and Determinants	1.79	1.86	1.82	1.42	1.68	1.22	.8
Maxwell's Equations	1.29	1.09	1.30	1.26	1.29	1.17	1.3
Numerical Analysis	1.88	1.86	1.64	1.45	1.68	1.89	1.6
Partial Differential Equations	1.12	1.18	1.39	1.47	1.36	1.11	1.1
Plane Trigonometry	2.17	2.64	2.55	2.66	2.57	2.72	2.1
Probability and Statistics	2.29	2.82	2.27	2.26	2.50	2.56	2.8
Presentations/Public Speaking	2.96	3.41	3.12	3.45	3.82	4.00	3.2
Technical Writing	3.29	3.05	2.94	3.47	3.68	3.39	3.2
State Variables	1.08	1.27	1.12	1.16	1.29	1.06	1.2
Vector Analysis	1.25	1.91	1.91	1.61	1.68	1.61	1.3
Z Transforms	1.12	1.27	1.18	1.16	1.32	1.06	1.1

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 10

A Comparison of Subject Use Frequency During the Entire Career and Years of Engineering Experience

Subject	Frequency[a]						
	1-3 Years	4-6 Years	7-10 Years	11-15 Years	16-20 Years	21-25 Years	25 Ye
Algebra	3.00	3.18	3.42	3.29	3.82	3.72	3.
Analytic Geometry	1.79	2.27	2.52	2.18	2.39	2.50	2.
Calculus	2.25	2.32	2.52	2.34	2.86	2.44	2.
Complex Variables	1.46	1.68	2.15	1.68	1.96	1.67	1.
Conformal Mapping	1.25	1.14	1.36	1.13	1.29	1.33	1.
Differential Equations	1.83	2.00	2.06	1.97	2.21	2.00	1.
Engineering Drawing/Draphics.	2.79	3.68	3.33	3.00	3.43	3.56	3.
Fourier Series/Integrals	1.46	1.86	1.76	1.58	2.00	1.56	1.
Descriptive Geometry	1.50	2.00	2.03	1.82	1.79	2.11	1.
Hyperbolic Trigonometry	1.21	1.55	1.39	1.24	1.46	1.22	1.
Infinite Series	1.42	1.45	1.73	1.42	1.75	1.50	1.
Laplace Transforms	1.58	1.64	2.03	1.74	2.18	1.44	1.
Matrices and Determinants	1.88	2.05	2.18	1.71	2.04	1.44	1.
Maxwell's Equations	1.37	1.23	1.52	1.34	1.29	1.78	1.
Numerical Analysis	1.88	2.18	1.76	1.61	1.82	2.00	1.
Partial Differential Equations	1.29	1.50	1.79	1.58	1.86	1.61	1.
Plane Trigonometry	2.42	2.91	3.00	2.82	2.93	3.33	2.
Probability and Statistics	2.33	2.86	2.61	2.34	2.86	2.67	2.
Presentations/Public Speaking	3.17	3.50	3.36	3.45	3.93	3.94	3.
Technical Writing	3.25	3.36	3.21	3.53	3.96	3.56	3.
State Variables	1.08	1.36	1.30	1.16	1.32	1.22	1.
Vector Analysis	1.37	2.09	2.06	1.76	2.21	2.17	2.
Z Transforms	1.12	1.18	1.33	1.26	1.39	1.11	1.

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response

Table 11

A Comparison of Subject Use Frequency During the Past Year and the Respondents Industry Affiliation

Subject	Frequency[a]												
	Broadcasting	Communication Utility	Computers	Consumer Goods	Consulting	Construction	Electrical Apparatus	Electronic Components	Government	Defense	Power Utility	Transportation	Other
Algebra	1.5	2.58	2.83	3.0	3.4	3.00	3.45	4.	3.19	3.44	3.00	3.0	3.00
Analytic Geometry	1.0	2.00	1.83	2.4	1.6	2.00	1.91	3.	1.76	2.15	1.90	1.6	1.65
Calculus	1.0	1.58	1.67	2.0	1.4	1.25	2.18	2.	2.10	2.59	1.98	2.0	1.62
Complex Variables	1.0	1.58	1.83	1.6	1.0	1.00	1.64	2.	1.71	1.52	1.50	1.2	1.35
Conformal Mapping	1.0	1.17	1.00	1.0	1.0	1.00	.82	1.	1.29	1.22	1.26	.8	1.04
Differential Equations	1.0	1.17	1.83	1.4	1.4	1.25	1.73	1.	1.81	2.00	1.57	1.6	1.23
Engrng. DWG./Graphics	1.0	3.08	2.00	3.6	4.6	4.00	2.55	4.	2.81	2.81	2.90	3.0	2.81
Fourier Series/Integrals	1.0	1.33	1.50	1.8	1.4	1.00	1.27	2.	1.90	2.00	1.36	1.8	1.27
Descriptive Geometry	1.0	1.67	1.17	1.8	2.0	1.75	.91	1.	1.48	1.56	1.69	1.0	1.42
Hyperbolic Trigonometry	1.0	1.25	1.00	1.2	1.0	1.00	1.18	1.	1.29	1.26	1.19	1.4	1.08
Infinite Series	1.0	1.17	1.00	1.2	1.0	1.00	1.27	1.	1.43	1.67	1.21	1.2	1.12
Laplace Transforms	1.0	1.17	1.67	1.4	1.0	1.50	1.73	2.	1.76	1.81	1.45	1.2	1.35
Matrices/Determinants	1.0	1.50	1.33	1.2	1.4	1.50	1.09	1.	1.90	1.74	1.57	1.8	1.54
Maxwell's Equations	1.0	1.17	1.00	1.0	1.2	1.00	.82	1.	1.62	1.44	1.29	1.2	1.08
Numerical Analysis	1.0	1.42	1.17	1.4	1.2	2.00	1.64	1.	1.86	1.93	1.81	2.2	1.31
Part'l. Diff. Eqtns.	1.0	1.00	1.33	1.6	1.2	1.25	1.18	1.	1.38	1.59	1.38	1.4	1.00
Plane Trigonometry	1.5	2.08	2.00	2.4	3.0	2.75	2.55	3.	2.57	2.56	2.64	2.4	2.54
Probability/Stat.	1.0	2.42	3.33	2.2	2.2	2.25	2.09	5.	2.86	2.74	2.21	3.0	2.04
Pres./Pub. Spkng.	1.5	3.33	3.50	3.2	3.2	3.75	3.55	5.	3.33	3.63	3.31	3.6	3.27
Technical Writing	3.5	3.25	3.50	3.4	3.8	3.25	3.18	4.	3.29	3.78	3.02	3.2	3.04
State Variables	1.0	1.17	1.00	1.0	1.0	1.00	1.09	1.	1.38	1.26	1.19	1.2	.96
Vector Analysis	1.0	1.25	1.17	1.4	1.8	1.00	1.45	1.	1.71	1.78	1.86	2.4	1.50
Z Transforms	1.0	1.17	1.00	1.0	1.0	1.00	.91	1.	1.38	1.26	1.24	1.0	1.15

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive Values shown represent mean response.

Table 12

A Comparison of Subject Use Frequency during the Respondents' Entire Career and Industry Affiliat

Subject	Frequency[a]												
	Broadcasting	Communication Utility	Computers	Consumer Goods	Consulting	Construction	Electrical Apparatus	Electronic Components	Government	Defense	Power Utility	Transportation	Other
Algebra	2.5	3.08	3.67	3.4	3.6	3.00	3.73	4.	3.57	3.59	3.10	3.4	3.42
Analytic Geometry	1.5	2.33	2.50	2.6	1.8	2.50	2.27	3.	2.38	2.41	2.26	1.2	2.04
Calculus	2.0	2.33	2.83	2.4	1.6	2.00	2.55	2.	2.57	2.89	2.24	2.8	2.23
Complex Variables	1.5	2.00	3.17	1.6	1.0	.75	1.91	2.	1.76	2.00	1.64	2.0	1.58
Conformal Mapping	1.0	1.08	1.00	1.2	1.4	1.00	1.09	1.	1.38	1.33	1.40	.8	1.12
Differential Equations	1.5	1.58	2.00	2.0	1.8	1.50	2.18	2.	2.05	2.41	2.00	2.4	1.65
Engineering Drawing/Draphics	3.5	3.50	2.50	4.0	3.6	4.00	2.64	4.	3.24	3.15	3.26	3.2	3.23
Fourier Series/Integral	1.5	1.75	1.50	1.4	1.2	1.50	1.36	2.	2.05	2.30	1.45	1.8	1.38
Descriptive Geometry	1.0	2.17	1.17	2.2	2.0	2.25	1.27	2.	1.76	1.81	2.05	1.2	1.88
Hyperbolic Trigonometry	1.0	1.42	1.17	1.2	1.0	1.50	1.36	2.	1.33	1.41	1.33	1.4	1.27
Infinite Series	1.0	1.50	1.00	1.4	1.2	1.50	1.45	2.	1.52	1.96	1.38	1.6	1.50
Laplace Transforms	1.0	1.58	1.67	1.4	1.0	1.50	2.00	2.	2.00	2.19	1.60	1.6	1.73
Matrices & Determinants	1.0	1.67	1.33	1.6	1.2	2.00	1.36	2.	2.29	2.00	1.79	2.0	2.00
Maxwell's Equations	1.0	1.58	.83	1.0	1.2	1.25	1.27	2.	1.67	1.78	1.36	1.4	1.12
Numerical Analysis	1.0	1.83	1.33	1.2	1.2	2.00	1.64	2.	2.05	2.04	1.88	2.4	1.58
Partial Diff. Equations	1.5	1.33	1.50	1.8	1.2	1.75	1.55	2.	1.86	1.85	1.50	2.2	1.31
Plane Trigonometry	2.5	2.42	2.67	2.4	3.0	3.00	2.82	4.	3.05	2.81	2.86	2.8	3.00
Probability & Statistics	1.0	2.58	3.00	2.6	2.0	2.50	2.27	4.	3.00	2.70	2.36	2.8	2.50
Presentations/Pub. Speak.	3.0	3.75	3.83	3.8	3.2	3.75	3.36	4.	3.43	3.70	3.36	3.6	3.42
Technical Writing	3.5	3.58	3.67	3.4	3.6	3.50	3.45	4.	3.52	3.89	3.14	3.2	3.38
State Variables	1.0	1.33	1.17	1.0	1.0	1.00	1.09	1.	1.29	1.37	1.29	1.2	1.08
Vector Analysis	1.0	1.75	1.67	1.2	2.0	2.00	1.73	1.	1.95	2.11	2.02	2.2	1.85
Z Transforms	1.0	1.25	1.00	1.0	1.0	1.00	.91	1.	1.48	1.41	1.21	1.4	1.23

[a]Frequency is expressed in values along a continuum where
1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive
Values shown represent mean response

Table 13

A Comparison of Subject Use Frequency During the Past Year and Status as a Professional Engineer (PE) or Engineer-in-Training (EIT)

Subject	Frequency[a]			
	PE	NON PE	EIT	NON EIT
Algebra	3.25	3.05	3.13	3.10
Analytic Geometry	1.82	1.91	2.00	1.86
Calculus	1.82	2.00	1.67	1.97
Complex Variables	1.59	1.46	1.27	1.53
Conformal Mapping	1.02	1.18	1.07	1.16
Differential Equations	1.45	1.62	1.47	1.60
Engineering Drawing/Draphics	2.82	2.95	3.00	2.86
Fourier Series/Integrals	1.30	1.60	1.33	1.54
Descriptive Geometry	1.50	1.51	1.33	1.52
Hyperbolic Trigonometry	1.18	1.19	1.07	1.19
Infinite Series	1.18	1.31	1.13	1.30
Laplace Transforms	1.32	1.60	1.53	1.53
Matrices and Determinants	1.43	1.65	1.87	1.58
Maxwell's Equations	1.20	1.26	1.33	1.24
Numerical Analysis	1.52	1.74	1.60	1.68
Partial Differential Equations	1.20	1.33	1.07	1.32
Plane Trigonometry	2.66	2.47	2.33	2.55
Probability and Statistics	2.32	2.47	2.07	2.43
Presentations/Public Speaking	3.48	3.36	2.93	3.39
Technical Writing	3.30	3.29	3.33	3.26
State Variables	1.14	1.18	1.20	1.18
Vector Analysis	1.68	1.64	1.40	1.68
Z Transforms	1.18	1.19	1.20	1.19

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 14

A Comparison of Subject Use Frequency During the Respondents Entire Career and Status as a Professional Engineer (PE) or Engineer-in-Training (EIT)

Subject	Frequency[a]			
	PE	NON PE	EIT	NON EIT
Algebra	3.57	3.31	3.40	3.39
Analytic Geometry	2.32	2.24	2.27	2.26
Calculus	2.30	2.47	2.20	2.45
Complex Variables	1.89	1.74	1.73	1.78
Conformal Mapping	1.11	1.29	1.13	1.27
Differential Equations	1.86	2.03	1.87	1.99
Engineering Drawing/Draphics	3.25	3.24	3.20	3.22
Fourier Series/Integrals	1.36	1.78	1.53	1.68
Descriptive Geometry	1.82	1.86	1.60	1.86
Hyperbolic Trigonometry	1.27	1.35	1.20	1.35
Infinite Series	1.41	1.58	1.53	1.54
Laplace Transforms	1.61	1.84	1.73	1.80
Matrices and Determinants	1.82	1.90	2.00	1.90
Maxwell's Equations	1.20	1.47	1.40	1.41
Numerical Analysis	1.59	1.91	1.73	1.83
Partial Differential Equations	1.57	1.62	1.53	1.62
Plane Trigonometry	2.93	2.84	2.53	2.88
Probability and Statistics	2.45	2.61	2.33	2.57
Presentations/Public Speaking	3.50	3.50	3.27	3.50
Technical Writing	3.50	3.45	3.27	3.45
State Variables	1.18	1.26	1.27	1.25
Vector Analysis	2.02	1.90	1.67	1.97
Z Transforms	1.18	1.27	1.27	1.26

[a]Frequency is expressed in values along a continuum were 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 15

A Comparison of Subject Use Frequency During the Past Year and Respondents Reported Supervisory Status

Subject	Frequency[a]			
	Individual Worker	Supervisor	Mid-Management	Upper Management
Algebra	3.17	2.95	3.09	3.27
Analytic Geometry	2.03	1.82	1.79	1.80
Calculus	2.29	1.91	1.67	1.67
Complex Variables	1.62	1.66	1.28	1.20
Conformal Mapping	1.09	1.23	1.14	1.13
Differential Equations	1.80	1.57	1.42	1.27
Engineering Drawing/Draphics	2.82	2.91	2.93	3.13
Fourier Series/Integrals	1.80	1.43	1.37	1.07
Descriptive Geometry	1.47	1.45	1.51	1.67
Hyperbolic Trigonometry	1.27	1.23	1.07	1.00
Infinite Series	1.50	1.20	1.14	1.00
Laplace Transforms	1.85	1.41	1.35	1.07
Matrices and Determinants	1.71	1.68	1.47	1.13
Maxwell's Equations	1.36	1.18	1.16	1.07
Numerical Analysis	1.74	1.66	1.77	1.20
Partial Differential Equations	1.38	1.30	1.30	1.07
Plane Trigonometry	2.55	2.48	2.63	2.33
Probability and Statistics	2.18	2.41	2.72	2.60
Presentations/Public Speaking	2.88	3.41	3.81	4.27
Technical Writing	3.32	3.55	2.98	3.20
State Variables	1.26	1.20	1.05	1.07
Vector Analysis	1.70	1.75	1.63	1.27
Z Transforms	1.29	1.16	1.12	1.07

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 16

A Comparison of Subject Use Frequency During the Respondents Entire Career and Reported Supervisory Status

Subject	Frequency[a]			
	Individual Worker	Supervisor	Mid-Management	Upper Management
Algebra	3.36	3.32	3.53	3.20
Analytic Geometry	2.24	2.20	2.35	2.13
Calculus	2.61	2.39	2.37	2.07
Complex Variables	1.86	1.98	1.56	1.53
Conformal Mapping	1.23	1.34	1.23	1.13
Differential Equations	2.12	2.11	1.91	1.40
Engineering Drawing/Draphics	3.02	3.32	3.37	3.47
Fourier Series/Integrals	1.88	1.66	1.53	1.20
Descriptive Geometry	1.71	1.95	1.88	1.80
Hyperbolic Trigonometry	1.42	1.39	1.21	1.07
Infinite Series	1.70	1.39	1.56	1.13
Laplace Transforms	2.14	1.57	1.56	1.40
Matrices and Determinants	1.91	1.93	1.88	1.40
Maxwell's Equations	1.47	1.30	1.42	1.27
Numerical Analysis	1.97	1.70	1.88	1.33
Partial Differential Equations	1.58	1.75	1.63	1.27
Plane Trigonometry	2.83	2.77	3.21	2.13
Probability and Statistics	2.24	2.61	3.02	2.33
Presentations/Public Speaking	3.18	3.48	3.79	4.13
Technical Writing	3.38	3.59	3.35	3.73
State Variables	1.27	1.32	1.12	1.27
Vector Analysis	1.77	2.02	2.16	1.67
Z Transforms	1.39	1.23	1.12	1.13

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 17

A Comparison of Subject Use Frequency During the Past Year and Respondents Reported Income Level

Subject	Frequency [a]							
	$5-10K	$10+-15K	$15+-20K	$20+-25K	$25+-30K	$30+-40K	$40+-50K	$50K+
Algebra	5.00	3.08	3.04	3.10	3.17	3.15	3.00	3.00
Analytic Geometry	1.00	1.77	1.93	1.95	1.83	2.00	1.67	1.00
Calculus	1.00	2.38	1.98	1.97	1.88	2.00	1.67	1.33
Complex Variables	1.00	1.31	1.56	1.60	1.33	1.55	1.33	.67
Conformal Mapping	1.00	1.31	1.27	1.13	1.00	1.05	1.00	.67
Differential Equations	1.00	2.00	1.49	1.53	1.79	1.70	1.00	1.00
Engineering Drawing/Draphics	2.00	3.23	3.02	2.70	3.13	3.00	3.33	2.00
Fourier Series/Integrals	1.00	1.92	1.51	1.52	1.42	1.75	1.00	.67
Descriptive Geometry	1.00	1.62	1.69	1.50	1.33	1.50	1.33	.67
Hyperbolic Trigonometry	1.00	1.38	1.20	1.15	1.21	1.20	1.00	.67
Infinite Series	1.00	1.69	1.20	1.32	1.12	1.40	1.33	.67
Laplace Transforms	1.00	1.92	1.53	1.55	1.50	1.45	1.33	.67
Matrices and Determinants	3.00	2.00	1.67	1.55	1.17	1.70	2.00	.67
Maxwell's Equations	1.00	1.62	1.29	1.17	1.04	1.60	1.00	.67
Numerical Analysis	1.00	2.38	1.62	1.58	1.62	1.80	2.00	.67
Partial Differential Equations	1.00	1.38	1.29	1.25	1.54	1.30	1.00	.67
Plane Trigonometry	5.00	2.23	2.67	2.63	2.37	2.35	2.67	1.33
Probability and Statistics	2.00	2.23	2.16	2.23	2.58	3.20	3.67	3.33
Presentations/Public Speaking	4.00	2.38	3.04	3.30	3.62	4.35	4.67	4.67
Technical Writing	2.00	3.38	3.09	3.27	3.67	3.45	2.67	2.67
State Variables	1.00	1.31	1.22	1.12	1.12	1.30	1.00	.67
Vector Analysis	1.00	1.46	1.82	1.82	1.25	1.55	1.67	.67
Z Transforms	1.00	1.31	1.29	1.17	.96	1.30	1.33	.67

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional 4 = frequent, 5 = extensive. Values shown represent mean response

Table 19

A Comparison of Subject Use Frequency During the Respondent's Entire Career and Reported Income Level

Subject	Frequency[a]							
	$5-10K	$10+-15K	$15+-20K	$20+-25K	$25+-30K	$30+-40K	$40+-50K	$50K+
Algebra	5.00	3.15	3.22	3.42	3.46	3.75	3.67	3.00
Analytic Geometry	1.00	2.00	2.07	2.37	2.37	2.55	2.33	1.33
Calculus	1.00	2.69	2.22	2.48	2.58	2.64	2.33	1.33
Complex Variables	1.00	1.54	1.76	1.93	1.67	1.70	1.67	1.33
Conformal Mappin[illegible]	1.00	1.62	1.31	1.22	1.17	1.15	1.33	.67
Differential Equacions	1.00	2.38	1.82	1.98	2.08	2.30	1.33	1.00
Engineering Drawing/Draphics	3.00	2.69	3.42	3.12	3.46	3.45	3.33	2.67
Fourier Series/Integrals	1.00	1.92	1.62	1.62	1.71	2.00	1.33	1.00
Descriptive Geometry	1.00	1.69	1.91	1.90	1.62	2.10	1.67	1.00
Hyperbolic Trigonometry	1.00	1.31	1.38	1.35	1.33	1.25	1.33	.67
Infinite Series	1.00	1.85	1.40	1.60	1.54	1.55	1.67	.67
Laplace Transforms	1.00	2.08	1.71	1.77	2.04	1.70	2.00	.67
Matrices and Determinants	3.00	2.08	1.76	1.88	1.83	2.05	2.33	.67
Maxwell's Equations	1.00	1.77	1.40	1.38	1.12	1.70	1.33	1.00
Numerical Analysis	1.00	2.46	1.82	1.72	1.67	2.05	1.67	1.00
Partial Differential Equations	1.00	1.54	1.44	1.58	1.92	1.90	1.33	1.00
Plane Trigonometry	4.00	2.46	2.84	2.98	2.92	3.00	3.33	.33
Probability and Statistics	4.00	1.92	2.29	2.48	2.79	3.03	3.67	2.33
Presentations/Public Speaking	4.00	2.85	3.20	3.52	3.79	3.95	4.33	4.33
Technical Writing	2.00	3.15	3.22	3.48	3.75	3.85	3.33	3.67
State Variables	1.00	1.31	1.29	1.18	1.29	1.25	1.67	.67
Vector Analysis	1.00	1.62	1.91	2.12	1.67	1.95	2.33	1.00
Z Transforms	1.00	1.31	1.29	1.25	1.12	1.35	1.67	.67

[a]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occassional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 20

A Comparison of Subject Use Frequency During the Past Year and Indicators of Respondents Satisfaction with Electrical Engineering as a Career.[a]

Subject	Frequency[b]			
	Would Rechoose Same Career		Would Recommend as a Career	
	Yes	No	Yes	No
Algebra	3.09	3.12	3.09	3.10
Analytic Geometry	1.99	1.67	1.95	1.75
Calculus	2.04	1.76	1.98	1.88
Complex Variables	1.50	1.47	1.51	1.45
Conformal Mapping	1.18	1.05	1.17	1.06
Differential Equations	1.68	1.36	1.64	1.43
Engineering Drawing/Draphics	3.04	2.67	2.98	2.80
Fourier Series/Integrals	1.59	1.36	1.54	1.47
Descriptive Geometry	1.60	1.31	1.56	1.39
Hyperbolic Trigonometry	1.28	1.00	1.25	1.06
Infinite Series	1.34	1.16	1.33	1.16
Laplace transforms	1.59	1.40	1.53	1.53
Matrices and Determinants	1.72	1.33	1.70	1.33
Maxwell's Equations	1.34	1.07	1.30	1.14
Numerical Analysis	1.80	1.45	1.80	1.41
Partial Differential Equations	1.36	1.16	1.34	1.18
Plane Trigonometry	2.54	2.47	2.57	2.35
Probability and Statistics	2.50	2.28	2.49	2.29
Presentations/Public Speaking	3.45	3.31	3.48	3.20
Technical Writing	3.28	3.33	3.25	3.41
State Variables	1.21	1.09	1.21	1.06
Vector Analysis	1.72	1.50	1.71	1.49
Z Transforms	1.22	1.10	1.21	1.12

[a] Respondents were asked to assume that they might somehow have the opportunity to re-initiate their career and to indicate if they would still choose the study of Electrical Engineering. They were also asked if they would recommend a career in Electrical Engineering to a young person about to enter college.

[b] Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

Table 21

A Comparison of Subject Use Frequency during the Respondents Entire Career and Indicators of Satisfaction with Electrical Engineering as a Career[a]

Subject	Frequency[b]			
	Would Rechoose Same Career		Would Recommend as a Career	
	Yes	No	Yes	No
Algebra	3.33	3.47	3.34	3.45
Analytic Geometry	2.37	2.02	2.33	2.10
Calculus	2.47	2.33	2.45	2.35
Complex Variables	1.78	1.76	1.79	1.75
Conformal Mapping	1.30	1.12	1.27	1.18
Differential Equations	2.03	1.90	2.02	1.90
Engineering Drawing/Draphics	3.34	3.05	3.28	3.20
Fourier Series/Integrals	1.77	1.48	1.71	1.59
Descriptive Geometry	1.98	1.57	1.96	1.57
Hyperbolic Trigonometry	1.47	1.05	1.43	1.10
Infinite Series	1.64	1.33	1.63	1.31
Laplace Transforms	1.86	1.60	1.83	1.67
Matrices and Determinants	2.02	1.59	2.02	1.53
Maxwell's Equations	1.50	1.21	1.50	1.18
Numerical Analysis	1.95	1.59	1.98	1.49
Partial Differential Equations	1.67	1.47	1.66	1.47
Plane Trigonometry	2.86	2.84	2.91	2.71
Probability and Statistics	2.64	2.43	2.64	2.43
Presentations/Public Speaking	3.53	3.48	3.54	3.45
Technical Writing	3.46	3.48	3.44	3.55
State Variables	1.31	1.09	1.30	1.10
Vector Analysis	2.04	1.69	2.01	1.75
Z Transforms	1.33	1.09	1.30	1.14

[a]Respondents were asked to assume that they might somehow have the opportunity to re-initiate their career and to indicate if they would still choose the study of Electrical Engineering. They were also asked if they would recommend a career in Electrical Engineering to a young person about to enter College.

[b]Frequency is expressed in values along a continuum where 1 = never, 2 = seldom, 3 = occasional, 4 = frequent, 5 = extensive. Values shown represent mean response.

SUBJECT ATTITUDES

Part 6 of the questionnaire requested extensive information relative to the respondents' attitudes for various aspects of the requirement for proficiency in the various subject areas. Reference to the questionnaire, and the tables that follow, will show the questions asked and data requested. Attitudes were expressed on an agree-disagree scale of six intervals. The low end of the scale "strongly disagree - no exception" was given the value of one while intermediate stages of disagreement - agreement progressed to "strongly agree - no exception" with a high value of six on the scale. The various degrees of agreement - disagreement were assumed to fall along a continuum of the assigned values. Actually, there were three degrees of disagreement and three degrees of agreement.

The mean response for the various subjects and questions has been entered directly into the questionnaire form. The mean, standard deviation, and percentage of respondents agreeing, have been listed separately in tabular form. These data appear in Tables 23 through 36. Table 22 summarizes the extent of majority agreement that subjects are required under various conditions.

A majority of respondents reported that their current and previous positions required Algebra, Analytic Geometry, Calculus, Engineering Drawing/Graphics, Plane Trigonometry, Probability/Statistics, Presentations/Public Speaking, and

Technical Writing. A majority also agreed that their associates holding Electrical Engineering assignments were required to demonstrate proficiency in these subjects. A majority reported that increased proficiency in Probability/ Statistics, Presentations/Public Speaking, and Technical Writing would enhance their prospects for advancement. These three subject areas were the only ones for which a majority indicated a desire for additional course work.

Despite the attitude as to subject requirement in their own environment, the majority of respondents indicated a requirement, in the undergraduate curriculum, for all of the listed subjects with the exception of Conformal Mapping, Hyperbolic Trigonometry, and Z Transforms. Even here, approximately forty percent expressed a requirement. Conformal Mapping, Hyperbolic Trigonometry, Infinite Series, Maxwell's Equations, State Variables and Z Transforms were dropped from the majority agreement list of subject proficiencies expected of a prospective Electrical Engineering employee. These data may be examined in detail in Tables 23 through 36.

An extremely strong Technology orientation is reflected in the respondents' attitude for their own environment. An extremely strong Engineering orientation is expressed in their attitude for required undergraduate course work and their expectations of a prospective employee. Whether this is due to the influence of educational experience or a firm conviction is not immediately evident.

TABLE 22

A SUMMARY COMPARISON OF SUBJECT AREAS AND MAJORITY AGREEMENT FOR THEIR REQUIREMENT

Subject	Majority Agreement						
	Current Position	Previous Positions	Advancement	Associates	Prospective Employee	Undergraduate Course Work	Continuing Education
Algebra	X	X		X	X	X	
Analytic Geometry	X	X		X	X	X	
Calculus	X	X		X	X	X	
Complex Variables					X	X	
Conformal Mapping							
Differential Equations					X	X	
Engineering Drawing/Graphics	X	X		X	X	X	
Fourier Series/Integrals					X	X	
Descriptive Geometry					X	X	
Hyperbolic Trigonometry							
Infinite Series						X	
Laplace Transforms					X	X	
Matrices and Determinants					X	X	
Maxwell's Equations						X	
Numerical Analysis					X	X	
Partial Differential Equations					X	X	
Plane Trigonometry	X	X		X	X	X	
Probability and Statistics	X	X	X	X	X	X	X
Presentation/Public Speaking	X	X	X	X	X	X	X
Technical Writing	X	X	X	X	X	X	X
State Variables							
Vector Analysis					X	X	
Z Transforms							

Table 23 Mean Response - Questionnaire Part VI-a

CURRENT POSITION

INSTRUCTIONS:

For each subject listed place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *My current position requires proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	←Disagree -0- Agree →					
	1	2	3	4	5	6
Algebra				●		
Analytic Geometry			●			
Calculus			●			
Complex Variables		●				
Conformal Mapping	●					
Differential Equations		●				
Engineering Drawing/Graphics				●		
Fourier Series/Integrals		●				
Descriptive Geometry		●				
Hyperbolic Trigonometry	●					
Infinite Series		●				
Laplace Transforms		●				
Matrices & Determinants		●				
Maxwell's Equations	●					
Numerical Analysis		●				
Partial Differential Equations		●				
Plane Trigonometry			●			
Probability and Statistics			●			
Presentations/Public Speaking					●	
Technical Writing				●		
State Variables	●					
Vector Analysis		●				
Z Transforms	●					

Table 24

A Comparison of Subject Areas and Extent of Agreement by Respondents that Subject Proficiency is Required in Their Current Position

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra	Yes	81.61	4.57	1.58
Analytic Geometry	Yes	51.15	3.19	1.72
Calculus	Yes	52.87	3.29	1.75
Complex Variables		27.59	2.43	1.60
Conformal Mapping		11.49	1.71	1.18
Differential Equations		33.33	2.70	1.70
Engineering Drawing/Graphics	Yes	75.29	4.39	1.67
Fourier Series/Integrals		25.86	2.40	1.67
Descriptive Geometry		31.03	2.55	1.58
Hyperbolic Trigonometry		14.37	1.83	1.35
Infinite Series		20.69	2.03	1.49
Laplace Transforms		27.59	2.34	1.71
Matrices and Determinants		32.76	2.58	1.78
Maxwell's Equations		18.97	1.98	1.46
Numerical Analysis		32.18	2.50	1.66
Partial Differential Equations		25.86	2.21	1.55
Plane Trigonometry	Yes	65.52	3.87	1.79
Probability and Statistics	Yes	60.34	3.64	1.77
Presentations/Public Speaking	Yes	87.36	5.01	1.32
Technical Writing	Yes	89.08	4.91	1.38
State Variables		12.64	1.76	1.28
Vector Analysis		29.89	2.55	1.81
Z Transforms		10.92	1.72	1.27

[a]Agreement is expressed in values along a continuum where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

Table 25. Mean Response - Questionnaire Part VI-b

PREVIOUS POSITIONS

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *Previous positions that I have held required proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree		◊	Agree →		
	1	2	3	4	5	6
Algebra				●		
Analytic Geometry			●			
Calculus			●			
Complex Variables		●				
Conformal Mapping	●					
Differential Equations		●				
Engineering Drawing/Graphics				●		
Fourier Series/Integrals		●				
Descriptive Geometry		●				
Hyperbolic Trigonometry	●					
Infinite Series		●				
Laplace Transforms		●				
Matrices & Determinants		●				
Maxwell's Equations		●				
Numerical Analysis		●				
Partial Differential Equations		●				
Plane Trigonometry				●		
Probability and Statistics			●			
Presentations/Public Speaking				●		
Technical Writing				●		
State Variables	●					
Vector Analysis		●				
Z Transforms	●					

Table 26

A Comparison of Subject Areas and Extent of Agreement by Respondents that Subject Proficiency has been Required in a Previous Position Held by them

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra	Yes	82.18	4.66	1.84
Analytic Geometry	Yes	58.05	3.47	1.90
Calculus	Yes	62.64	3.66	1.97
Complex Variables		33.91	2.66	1.84
Conformal Mapping		12.64	1.65	1.28
Differential Equations		39.66	2.84	1.87
Engineering Drawing/Draphics.	Yes	75.86	4.41	1.85
Fourier Series/Integrals		33.91	2.52	1.80
Descriptive Geometry		41.95	2.77	1.84
Hyperbolic Trigonometry		17.24	1.88	1.49
Infinite Series		25.86	2.20	1.68
Laplace Transforms		30.46	2.51	1.84
Matrices and Determinants		39.66	2.77	1.89
Maxwell's Equations		21.26	2.03	1.66
Numerical Analysis		33.91	2.54	1.83
Partial Differential Equations		32.18	2.40	1.73
Plane Trigonometry	Yes	71.84	4.07	1.92
Probability and Statistics	Yes	59.20	3.62	1.93
Presentations/Public Speaking	Yes	81.61	4.56	1.78
Technical Writing	Yes	84.48	4.60	1.77
State Variables		11.49	1.68	1.30
Vector Analysis		37.93	2.66	1.98
Z Transforms		10.92	1.66	1.32

[a]Agreement is expressed in values along a continuum where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

Table 27. Mean Response - Questionnaire Part VI-c

ADVANCEMENT

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *Advancement with my present employer would be enhanced if I had greater proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	←Disagree -0- Agree →					
	1	2	3	4	5	6
Algebra		●				
Analytic Geometry		●				
Calculus		●				
Complex Variables	●					
Conformal Mapping	●					
Differential Equations		●				
Engineering Drawing/Graphics		●				
Fourier Series/Integrals	●					
Descriptive Geometry	●					
Hyperbolic Trigonometry	●					
Infinite Series	●					
Laplace Transforms	●					
Matrices & Determinants		●				
Maxwell's Equations	●					
Numerical Analysis		●				
Partial Differential Equations	●					
Plane Trigonometry		●				
Probability and Statistics			●			
Presentations/Public Speaking				●		
Technical Writing				●		
State Variables	●					
Vector Analysis	●					
Z Transforms	●					

Table 28.

A Comparison of Subject Areas and Extent of Agreement by Respondents that their Advancement would be Enhanced if they had Greater Proficiency in the Subject

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra		28.74	2.39	1.65
Analytic Geometry		19.54	2.11	1.46
Calculus		28.16	2.25	1.53
Complex Variables		17.82	1.95	1.39
Conformal Mapping		9.77	1.61	1.17
Differential Equations		20.11	2.05	1.45
Engineering Drawing/Draphics.		35.06	2.64	1.72
Fourier Series/Integrals		16.09	1.90	1.34
Descriptive Geometry		16.67	1.89	1.43
Hyperbolic Trigonometry		8.62	1.55	1.10
Infinite Series		13.22	1.69	1.21
Laplace Transforms		16.67	1.90	1.40
Matrices and Determinants		21.84	2.13	1.49
Maxwell's Equations		9.77	1.63	1.16
Numerical Analysis		21.26	2.14	1.63
Partial Differential Equations		16.09	1.89	1.38
Plane Trigonometry		22.99	2.25	1.54
Probability and Statistics	Yes	51.15	3.30	1.88
Presentations/Public Speaking	Yes	83.91	4.85	1.73
Technical Writing	Yes	79.31	4.48	1.84
State Variables		9.77	1.65	1.14
Vector Analysis		20.11	1.97	1.45
Z Transforms		8.62	1.62	1.19

[a]Agreement is expressed in values along a continuum where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

Table 29. Mean Response - Questionnaire Part VI-d

ASSOCIATES

INSTRUCTIONS:

For each subject listed place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *I believe that most of my associates, holding electrical engineering assignments, are required to demonstrate proficiency in this subject.*

SCALE VALUES:
1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree		-0-	Agree →		
	1	2	3	4	5	6
Algebra				●		
Analytic Geometry			●			
Calculus			●			
Complex Variables		●				
Conformal Mapping	●					
Differential Equations			●			
Engineering Drawing/Graphics				●		
Fourier Series/Integrals		●				
Descriptive Geometry		●				
Hyperbolic Trigonometry	●					
Infinite Series		●				
Laplace Transforms		●				
Matrices & Determinants		●				
Maxwell's Equations		●				
Numerical Analysis		●				
Partial Differential Equations		●				
Plane Trigonometry			●			
Probability and Statistics			●			
Presentations/Public Speaking				●		
Technical Writing				●		
State Variables		●				
Vector Analysis		●				
Z Transforms		●				

Table 30

A Comparison of Subject Areas and Extent of Agreement by Respondents that their Associates holding Electrical Engineering Assignments are Required to Demonstrate Proficiency in the Subject

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra	Yes	78.74	4.51	1.72
Analytic Geometry	Yes	55.17	3.48	1.76
Calculus	Yes	60.92	3.72	1.77
Complex Variables		39.66	2.94	1.73
Conformal Mapping		13.79	1.91	1.32
Differential Equations		44.25	3.04	1.70
Engineering Drawing/Draphics.	Yes	66.67	4.13	1.70
Fourier Series/Integrals		37.93	2.78	1.68
Descriptive Geometry		38.51	2.82	1.75
Hyperbolic Trigonometry		17.24	1.99	1.36
Infinite Series		31.61	2.45	1.62
Laplace Transforms		38.51	2.78	1.79
Matrices and Determinants		37.93	2.90	1.79
Maxwell's Equations		25.29	2.35	1.58
Numerical Analysis		36.21	2.75	1.76
Partial Differential Equations		36.21	2.74	1.67
Plane Trigonometry	Yes	66.09	3.94	1.79
Probablility and Statistics	Yes	57.47	3.58	1.78
Presentations/Public Speaking	Yes	81.61	4.42	1.54
Technical Writing	Yes	84.48	4.47	1.55
State Variables		20.11	2.13	1.43
Vector Analysis		39.08	2.77	1.83
Z Transforms		17.82	2.04	1.48

[a]Agreement is expressed in values along a continuum where 1 - strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

Table 31. Mean Response - Questionnaire Part VI-e

MANAGER

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *From the viewpoint of a manager or supervisor, I would expect a prospective employee for an electrical engineering position to have proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree -Φ- Agree →					
	1	2	3	4	5	6
Algebra					●	
Analytic Geometry				●		
Calculus				●		
Complex Variables			●			
Conformal Mapping		●				
Differential Equations			●			
Engineering Drawing/Graphics				●		
Fourier Series/Integrals			●			
Descriptive Geometry			●			
Hyperbolic Trigonometry		●				
Infinite Series			●			
Laplace Transforms			●			
Matrices & Determinants			●			
Maxwell's Equations			●			
Numerical Analysis			●			
Partial Differential Equations			●			
Plane Trigonometry				●		
Probability and Statistics				●		
Presentations/Public Speaking				●		
Technical Writing				●		
State Variables		●				
Vector Analysis			●			
Z Transforms		●				

Table 32

A Comparison of Subject Areas and the Extent of Agreement, from the Viewpoint of a Manager, that Subject Proficiency would be Expected in a Prospective Electrical Engineering Employee

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra	Yes	93.10	5.22	1.34
Analytic Geometry	Yes	76.44	4.30	1.64
Calculus	Yes	87.36	4.70	1.49
Complex Variables	Yes	56.90	3.63	1.77
Conformal Mapping		24.14	2.30	1.54
Differential Equations	Yes	60.34	3.86	1.69
Engineering Drawing/Draphics.	Yes	85.06	4.72	1.44
Fourier Series/Integrals	Yes	52.87	3.54	1.74
Descriptive Geometry	Yes	52.30	3.39	1.75
Hyperbolic Trigonometry		31.61	2.49	1.62
Infinite Series		44.25	3.05	1.73
Laplace Transforms	Yes	55.75	3.63	1.81
Matrices and Determinants	Yes	53.45	3.60	1.76
Maxwell's Equations		39.08	3.00	1.70
Numerical Analysis	Yes	53.45	3.32	1.82
Partial Differential Equations	Yes	51.72	3.51	1.66
Plane Trigonometry	Yes	82.76	4.65	1.52
Probability and Statistics	Yes	68.97	4.14	1.67
Presentations/Public Speaking	Yes	90.80	4.82	1.30
Technical Writing	Yes	91.95	4.95	1.31
State Variables		28.74	2.51	1.50
Vector Analysis	Yes	54.02	3.46	1.85
Z Transforms		30.46	2.49	1.64

[a]Agreement is expressed in values along a continuum where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

Table 33. Mean Response - Questionnaire Part VI-f

COURSE WORK

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *Based upon my own work experience, I believe that undergraduate Electrical Engineering students should have course work in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exceptions

	← Disagree -0- Agree →					
	1	2	3	4	5	6
Algebra					●	
Analytic Geometry					●	
Calculus					●	
Complex Variables				●		
Conformal Mapping		●				
Differential Equations				●		
Engineering Drawing/Graphics					●	
Fourier Series/Integrals				●		
Descriptive Geometry				●		
Hyperbolic Trigonometry			●			
Infinite Series			●			
Laplace Transforms				●		
Matrices & Determinants				●		
Maxwell's Equations			●			
Numerical Analysis			●			
Partial Differential Equations				●		
Plane Trigonometry					●	
Probability and Statistics				●		
Presentations/Public Speaking					●	
Technical Writing					●	
State Variables			●			
Vector Analysis				●		
Z Transforms			●			

Table 34

A Comparison of Subject Areas and the Extent of Agreement by Respondents that they believe that Undergraduate Electrical Engineering Students should have Course Work in the Subject

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra	Yes	95.40	5.59	1.20
Analytic Geometry	Yes	86.78	5.09	1.55
Calculus	Yes	95.40	5.45	1.25
Complex Variables	Yes	78.16	4.37	1.59
Conformal Mapping		37.36	2.84	1.58
Differential Equations	Yes	83.91	4.82	1.50
Engineering Drawing/Draphics.	Yes	93.68	5.34	1.18
Fourier Series/Integrals	Yes	79.89	4.47	1.58
Descriptive Geometry	Yes	71.84	4.24	1.74
Hyperbolic Trigonometry		48.28	3.25	1.71
Infinite Series	Yes	62.64	3.84	1.70
Laplace Transforms	Yes	78.16	4.43	1.58
Matrices and Determinants	Yes	78.16	4.45	1.60
Maxwell's Equations	Yes	59.77	3.80	1.78
Numerical Analysis	Yes	67.82	3.99	1.66
Partial Differential Equations	Yes	75.29	4.23	1.54
Plane Trigonometry	Yes	91.95	5.28	1.24
Probability and Statistics	Yes	87.36	4.86	1.43
Presentations/Public Speaking	Yes	95.40	5.48	1.09
Technical Writing	Yes	95.40	5.52	1.07
State Variables	Yes	43.68	3.13	1.59
Vector Analysis	Yes	64.94	4.09	1.73
Z Transforms		43.68	3.09	1.70

[a]Agreement is expressed in values along a continuum where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

Table 35. Mean Response - Questionnaire Part VI-g

CONTINUING EDUCATION

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *I would like the opportunity to participate in a formal course of study to gain greater proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree - 0 - Agree →					
	1	2	3	4	5	6
Algebra	●					
Analytic Geometry	●					
Calculus		●				
Complex Variables		●				
Conformal Mapping	●					
Differential Equations		●				
Engineering Drawing/Graphics		●				
Fourier Series/Integrals		●				
Descriptive Geometry	●					
Hyperbolic Trigonometry	●					
Infinite Series	●					
Laplace Transforms		●				
Matrices & Determinants		●				
Maxwell's Equations	●					
Numerical Analysis		●				
Partial Differential Equations		●				
Plane Trigonometry	●					
Probability and Statistics			●			
Presentations/Public Speaking				●		
Technical Writing			●			
State Variables	●					
Vector Analysis		●				
Z Transforms	●					

Table 36

A Comparison of Subject Areas and the Extent of Agreement by Respondents that they would like the Opportunity to Participate in a Formal Course of Study to Gain Greater Proficiency in the Subject

Subject	Majority Agreement	Percent of Respondents Agreeing	Mean Agreement[a]	Standard Deviation
Algebra		12.64	1.80	1.39
Analytic Geometry		13.79	1.80	1.39
Calculus		20.69	2.01	1.52
Complex Variables		14.37	1.90	1.46
Conformal Mapping		8.62	1.66	1.28
Differential Equations		21.26	2.02	1.50
Engineering Drawing/Draphics		20.69	2.03	1.62
Fourier Series/Integrals		16.09	1.97	1.54
Descriptive Geometry		11.49	1.67	1.28
Hyperbolic Trigonometry		9.20	1.65	1.26
Infinite Series		13.22	1.74	1.37
Laplace Transforms		17.82	1.95	1.56
Matrices and Determinants		24.71	2.18	1.67
Maxwell's Equations		10.92	1.74	1.43
Numerical Analysis		30.46	2.34	1.78
Partial Differential Equations		18.97	1.95	1.48
Plane Trigonemetry		14.37	1.79	1.42
Probability and Statistics	Yes	58.05	3.47	2.11
Presentations/Public Speaking	Yes	64.37	3.90	2.07
Technical Writing	Yes	60.34	3.71	2.10
State Variables		12.07	1.71	1.35
Vector Analysis		18.39	1.93	1.58
Z Transforms		10.34	1.69	1.40

[a]Agreement is expressed in values along a continuum where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. See Questionnaire Part VI.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

This study was undertaken to compare a spectrum of functions or activities and subject proficiencies, as experienced by engineering practitioners, with core characteristics of the Electrical Engineering and Electrical Engineering Technology curricula. Electrical Engineering graduates and related curricula of the University of Alabama were chosen for study. An answer to the specific question - Is the practice of Electrical Engineering, by a majority of practitioners, closer to that envisioned by the Electrical Engineering or by the Electrical Engineering Technology curriculum? - was to be inferred from the results of the study.

Reference to the current curricula at the University of Alabama (see Appendix B) shows similarities and differences in the two programs. They are similar in that they both have a core of technical specialty courses that are virtually indistinguishable. Major differences include the following:

1. The technology curriculum begins the freshman year with Algebra and Trigonometry. The engineering curriculum begins with Analytic Geometry and Calculus.

2. The technology curriculum requires two courses in Engineering Drawing and two courses in English Composition. The engineering curriculum requires only one of each.

3. The technology curriculum includes a one semester course in each of the four areas; Technical Writing, Speech, Management and Legal Aspects. There are no similar requirements in engineering.

4. The engineering curriculum allows for greater flexibility than does that for technology in that fewer courses fall into the required category. Engineering allows a greater freedom in choice of electives.

Reference to the survey instrument (Appendix A) shows that it requested information or data relevant to the described curricular differences. Results of the survey, contained in Chapter IV, indicate characteristics of the respondents representing their requirements for mathematics and non technical subject material. A consideration of the curricula and the survey results indicates that the educational needs of a majority of respondents could have been adequately served by the mathematics levels of the technology curriculum. The respondents would have been better served, in their need for non technical and administrative type material, by the technology curriculum. It may be concluded that the practice of Electrical Engineering, by a majority of respondents, is closer to that envisioned by the Electrical Engineering Technology curriculum than by the Electrical Engineering curriculum.

The survey results provide data for inferring answers to related questions. For example, there is evidence that there has been justification for the two closely related but separate programs. It has been indicated that a majority of the survey respondents have needs that would have been appropriately served by a technology program. There is also a significant number having need for or preferring characteristics of the engineering program. For the future, it may become desirable to move toward a four-year engineering technology oriented program as the first engineering degree with graduate study available to those seeking greater specialization or "in depth" concentration.

The study provides data showing that many engineers, holding professional registration, have indicated educational needs that could have been satisfied by the philosophy of technology education. By present definitions, and the example of already registered engineers, there is no educational justification for excluding Engineering Technology graduates of the University of Alabama from seeking registration as a Professional Engineer.

For the present, a problem of communication remains to be solved. The survey respondents indicated a strong orientation toward the engineering curriculum in their attitude toward the requirements of undergraduate course work and their expectations of a prospective employee. A technology orientation was expressed for their own

environment. It is probable that this conflict has origins involving both status and educational experience rather than the reality representing practice. Dissemination of information, such as the results of this study, may eventually aid resolution of the apparent conflict.

Recommendations

As a result of this study and based upon its findings, the following recommendations are made:

1. That a comphrehensive study be initiated at the national level to examine and define the relationships between engineering practice and the spectrum of mathematics necessary in the preparation of engineers and technologists. Industry participation at the practitioner level should be strongly encouraged. Criteria for curricula and their accreditation should be aimed toward compatibility with the requirements of practice.

2. That further study be given to the desirability of promoting a four-year engineering technology oriented program as the first engineering degree with graduate study available to those seeking greater specialization or "in depth" concentration. Electrical engineering students should be encouraged to elect practice oriented courses and those shown by this study to be highly relevant to industrial practice.

3. A public relations activity is needed having objectives of educating faculty, employers, practitioners, legislators, counselors and students to the objectives and

advantages of the technology approach to career education. The results of this and similar studies can form a base for establishing credibility.

4. That ASEE and ECPD be encouraged to study and redefine Engineering Technology. Much of the confusion and misconceptions regarding engineering technology have their origins in definitions that were originated for the two year Associate dgree programs and prior to emergence of the Baccalaureate programs. The term "technologist" has not been accepted by industry. It seems appropriate to seek redefinition in terms of industrial practice in preference to a perpetuation of the present definition that implies subprofessional status.

5. That the curriculum in Electrical Engineering Technology at the University of Alabama be revised to more fully exploit the subject emphasis highlighted by this study.

Implications for Educational Practice

The results of this study would probably come as no great surprise to many industrial practitioners. The writer of this report has over twenty years of industrial experience. Over this period of time he observed that many engineers, especially new graduates, appeared to be disillusioned as a result of what appeared to be a major disparity between their technical education and the requirements of their industry assignment. Many informal discussions led to an

impression that higher level mathematics was seldom required or applied outside of academic situations. The application of higher mathematics, by many practicing engineers, seemed to be confined to those instances whereby the individual might be involved in some form of continuing education or in preparing for professional registration examination. Similar discussions with engineering managers indicated that many engineers receiving periodic pay increases and "satisfactory" performance evaluations did not have assignments where proficiency in higher mathematics was being demonstrated. The evidence was confusing since a major portion of the undergraduate curricula, provided in preparation for such positions, have been directed toward the study of mathematics and to mathematical analysis in an area of specialization.

These observations were also discussed with engineering educators. The general consensus seemed to be that such individuals in industry were not doing "real" engineering work and that those not making use of their educational background were only deceiving themselves about their knowledge of the "real" problems of engineering. Furthermore, anyone receiving an engineering degree should be prepared for advancement into the highest positions in research and development or at least to engineering management in areas oriented to such activity. It was considered unfortunate that some graduates were apparently not motivated to strive for such status.

> The history of engineering education and the engineering profession is a very difficult heritage to overcome in reconciling different opinions on what constitutes professionalism and engineering work. The practitioners of engineering from the very beginning had little involvement in the development of engineering education. This role fell primarily upon the educators with minimum assistance from the founder societies and practitioners (Irwin, 1974 p. 29).

With minimum impact or input from industrial practpractitioners and engineering work perceived through the eyes of those concerned with research and graduate study, it would seem inevitable that the realities of engineering practice involving such activities as manufacturing, testing, processes, procedures, operations or maintenance might be ignored.

Courses for the new engineering technology programs at the University of Alabama were initiated in 1972. They have been developed on a year by year basis as the need arose. The spring of 1976 will see the first graduates emerge. It has become evident, for a number of reasons, that the curricula must be substantially rearranged and revised. Greater flexibility is needed to better accommodate junior or community college transfers, and the varied backgrounds of high school students. Graduates must achieve acceptance and preparations for accreditation must begin in earnest. Fortunately, the programs and the involved faculty are not now firmly committed to any established tradition. Opportunities for modification and improvement still exist.

Thus, this study, whereby information having

potential to influence curriculum revision was secured from alumni, comes at an opportune time. Considerable insight has been provided toward defining and substantiating the spectrum of functions, activities and proficiencies likely to be required of graduates in industry. These facts, as opposed to opinions, may help to establish credibility for proposed changes. Curriculum revisions have the opportunity to be influenced by documented information rather than mere personal conviction. Several proposed changes have already received preliminary approval as a result of the emphasis highlighted by this study.

From a broader perspective, ASEE has recently begun to discuss the need to "formulate" a study that will clarify the engineering spectrum. Some time may elapse before the results of such study will be available. The documentation provided by this MARP may be able to influence or contribute to such studies.

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APPENDIX A

Cover letter and submitted questionnaire.

WILLIAM S. BYERS
THE UNIVERSITY OF ALABAMA
BOX 798
UNIVERSITY, AL. 35486

To:
University of Alabama
Electrical Engineering
Graduates

Dear Sir:

Your help is requested.

Considerable effort has been and continues to be directed to the study of engineering education and ways that the curricula can be made more relevant to the requirements of industry. Programs are continually being reexamined in an effort to find better ways to achieve a balance between preparing students for engineering practice while maintaining a strong base in fundamentals.

As a graduate engineer, you may contribute significantly to one such study. By completing the attached questionnaire you may help to define the spectrum of functions or activities and subject proficiencies appropriate to one who has been confronted with the realities of engineering practice.

The survey is directed at this time to graduates in electrical engineering of the University of Alabama since 1950. The resulting information may be of considerable value for influencing future revisions of the engineering and technology curricula. The study will also form a part of my own research in curriculum. Your response will be anonymous and used only for statistical purposes. However, you may request a summary of the survey results.

Thank you very much for your assistance. A self addressed and stamped envelope is provided for your convenience. Your prompt reply will be appreciated.

Sincerely,

William S. Byers.

William S. Byers
Principal Investigator
Engineering Practitioner Project

WSB/b

PART I

GENERAL BACKGROUND

INSTRUCTIONS:

Please check the appropriate space for each of the items listed below.

1. Are you currently employed in a position classified as Electrical Engineering? Yes___ No___

2. How many years of engineering experience do you have?
1-3___ 4-6___ 7-10___ 11-15___ 16-20___ 21-25___ 25+___

3. What is the highest degree, in Engineering, earned by you?
BS___ MS___ Doctorate___

4. In what type of Industry is your current employment?
Broadcasting___ Communications Utility___ Computers___
Consumer Goods___ Consulting___ Construction Industry___
Education___ Electrical Apparatus___ Electronic Components___
Government___ Military/Defense Industry___ Power Utility___
Semiconductor Mfg.___ Transportation___ Other (specify)_____

5. Are you a registered Professional Engineer? Yes___ No___
or Engineer-in-Training? Yes___ No___

6. Is your present position best described as: Individual Technical Worker___ Supervisor___ Mid Management___ Upper Management___

7. What is your approximate income per year from engineering employment or service? 5-10K___ 10,001-15K___ 15,001-20K___ 20,001-25K___ 25,001-30K___ 30,001-40K___ 40,001-50K___ 50K+___

8. If your position involves supervision, what is the number of employees supervised? 1-3___ 4-6___ 7-10___ 11-20___ 20+___

9. Assume that you might somehow have the opportunity to re-initiate your career. Based upon your own work experience would you still choose the study of Electrical Engineering? Yes___ No___

10. Would you recommend a career in Electrical Engineering to a young person preparing to enter college? Yes___ No___

11. Are you interested in receiving a report on the results of this survey? Yes___ No___

Your response to this survey is to be used for statistical purposes only. However, if you wish to receive a report of the results, please supply your name and address on the attached postcard.

PART II

FUNCTIONS

INSTRUCTIONS:

Please estimate the approximate time, as a percentage of your total working time, which you spend, during an average work week performing the following functions. It is realized that the total of these estimates may not add up to exactly 100 percent.

Administration . . . . . ___%
Construction . . . . . ___%
Consulting . . . . . ___%
Design . . . . . ___%
Development. . . . . ___%
Estimating . . . . . ___%
Maintenance . . . . . ___%
Management-Nontechnical. . . . . ___%
Management-Technical . . . . . ___%
Operations and/or Production . . . . ___%
Planning . . . . . ___%
Quality Control. . . . . ___%
Research--Applied. . . . . ___%
Research--Basic. . . . . ___%
Sales--Applications Engineering. . . ___%
Testing. . . . . ___%
Other (please specify _____ ___%

_____

_____

_____

PART III

ACTIVITIES

INSTRUCTIONS:

Please estimate the approximate amount of time, as a percentage of your total time, which you spend, during an average work week in the following activities. It is realized that the total of these estimates may not add up to exactly 100 percent.

Conferences. . . . . ___ %

Consulting . . . . . ___ %

Coordination . . . . . ___ %

Correspondence . . . . . ___ %

Drafting . . . . . ___ %

Estimating . . . . . ___ %

Field Work . . . . . ___ %

Laboratory Work. . . . . ___ %

Nonroutine Calculation . . . . . ___ %

Planning . . . . . ___ %

Presentations. . . . . ___ %

Research . . . . . ___ %

Study. . . . . ___ %

Supervision. . . . . ___ %

Technical Writing. . . . . ___ %

Other (please specify) _____ %

_____

_____

_____

PART IV

PAST YEAR

INSTRUCTIONS:

Please place a check mark in the block which best describes your use of the following subjects in the performance of your work duties during the past year.

	Never	Seldom	Occasional	Frequent	Extensive
Algebra					
Analytic Geometry					
Calculus					
Complex Variables					
Conformal Mapping					
Differential Equations					
Engineering Drawing/Graphics					
Fourier Series/Integrals					
Descriptive Geometry					
Hyperbolic Trigonometry					
Infinite Series					
Laplace Transforms					
Matrices & Determinants					
Maxwell's Equations					
Numerical Analysis					
Partial Differential Equations					
Plane Trigonometry					
Probability and Statistics					
Presentations/Public Speaking					
Technical Writing					
State Variables					
Vector Analysis					
Z Transforms					

PART V

ENTIRE CAREER

INSTRUCTIONS:

Please place a check in the block which best describes your use of the following subjects in the performance of your work duties during your entire career.

	Never	Seldom	Occasional	Frequent	Extensive
Algebra					
Analytic Geometry					
Calculus					
Complex Variables					
Conformal Mapping					
Differential Equations					
Engineering Drawing/Graphics					
Fourier Series/Integrals					
Descriptive Geometry					
Hyperbolic Trigonometry					
Infinite Series					
Laplace Transforms					
Matrices & Determinants					
Maxwell's Equations					
Numerical Analysis					
Partial Differential Equations					
Plane Trigonometry					
Probability and Statistics					
Presentations/Public Speaking					
Technical Writing					
State Variables					
Vector Analysis					
Z Transforms					

PART VI-a

CURRENT POSITION

INSTRUCTIONS:

For each subject listed place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *My current position requires proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	←Disagree -ϕ- Agree →					
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
Maxwell's Equations						
Numerical Analysis						
Partial Differential Equations						
Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

PART VI-b

PREVIOUS POSITIONS

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *Previous positions that I have held required proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree - ◊ - Agree →					
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
Maxwell's Equations						
Numerical Analysis						
Partial Differential Equations						
Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

PART VI-c

ADVANCEMENT

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *Advancement with my present employer would be enhanced if I had greater proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	←Disagree			◊	Agree →	
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
Maxwell's Equations						
Numerical Analysis						
Partial Differential Equations						
Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

PART VI-d

ASSOCIATES

INSTRUCTIONS:

For each subject listed place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *I believe that most of my associates, holding electrical engineering assignments, are required to demonstrate proficiency in this subject.*

SCALE VALUES:
1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree			◊	Agree →	
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
Maxwell's Equations						
Numerical Analysis						
Partial Differential Equations						
Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

PART VI-e

MANAGER

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *From the viewpoint of a manager or supervisor, I would expect a prospective employee for an electrical engineering position to have proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree -0- Agree →					
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
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Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

PART VI-f

COURSE WORK

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *Based upon my own work experience, I believe that undergraduate Electrical Engineering students should have course work in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exceptions

	←Disagree			↔	Agree →	
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
Maxwell's Equations						
Numerical Analysis						
Partial Differential Equations						
Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

PART VI-g

CONTINUING EDUCATION

INSTRUCTIONS:

For each subject listed below, place a check in the block which indicates the extent of your agreement with the following statement.

STATEMENT: *I would like the opportunity to participate in a formal course of study to gain greater proficiency in this subject.*

SCALE VALUES:

1. Strongly disagree - no exception
2. Disagree - minor reservation
3. Slightly disagree
4. Slightly agree
5. Agree with minor reservation
6. Strongly agree - no exception

	← Disagree - Agree →					
	1	2	3	4	5	6
Algebra						
Analytic Geometry						
Calculus						
Complex Variables						
Conformal Mapping						
Differential Equations						
Engineering Drawing/Graphics						
Fourier Series/Integrals						
Descriptive Geometry						
Hyperbolic Trigonometry						
Infinite Series						
Laplace Transforms						
Matrices & Determinants						
Maxwell's Equations						
Numerical Analysis						
Partial Differential Equations						
Plane Trigonometry						
Probability and Statistics						
Presentations/Public Speaking						
Technical Writing						
State Variables						
Vector Analysis						
Z Transforms						

APPENDIX B

Electrical Engineering

and

Electrical Engineering Technology

Curricula

Electrical Engineering Curriculum

First Semester

			Hours
CH	115	General Chemistry	5
DR	109	Introduction to Engineering Drawing	2
EH	141	English Composition	3
GES	125	Engineering—A Creative Profession	2
MA	125	Analytic Geometry and Calculus	4
			16

Second Semester

		Literature	3
GES	126	Engineering Computer Science	3
MA	126	Calculus and Analytic Geometry	4
MH	161	Statics	3
EC	101	Principles of Economics, Part I	3
			16

SOPHOMORE YEAR

First Semester

			Hours
EE	220	Electronic Instrumentation	4
MA	227	Calculus	4
MH	162	Particle Dynamics	2
		I. C. Elective	3
		Humanities Elective	3
			16

Second Semester

EE	230	Electrical Science	4
MA	253	Differential Equations	3
PH	107	Technical Physics	5
		Humanities Elective	3
			15

JUNIOR YEAR

First Semester

EE	322	Electronics I	3
EE	331	Network Analysis	3
EE	341	Electromagnetics I	3
PH	253	Modern Physics	3
		Mathematics Elective	3
			15

Second Semester

EE	324	Electronics II	3
EE	360	Quantum Electronics	3
EE	370	Signals and Systems	3
EE	343	Electromagnetics II	2
		Mathematics Elective	3
		Humanities Elective	3
			17

SENIOR YEAR

First Semester

EE		Senior Laboratory Elective	1
EE		Electives	9
		Free Elective	3
		Humanities Elective	3
			16

Second Semester

EE		Senior Laboratory Elective	1
EE		Electives	9
		Free Elective	3
		I. C. Elective	4
			17

Electrical Engineering Technology Curriculum

First Semester

			Hours
EH	101	English Composition I	3
MA	109	College Algebra	3
MA	115	Analytic Trigonometry	3
DR	109	Drawing	2
PH	101	Physics I	4
ET	101	Technology Laboratory I	1
			16

Second Semester

EH	102	English Composition II	3
DR	115	Engineering Drawing	2
ET	102	Technology Laboratory II	1
ET	111	Applied Mathematics I	5
ET PH	214 102	Statics/Dynamics (CET) or Physics II (EET & MET)	4
			15

SOPHOMORE YEAR

First Semester

			Hours
ET	211	Applied Mathematics II	3
ET	251	Fundamentals of Electricity	2
CH	101	Chemistry I	4
ET	255	Electric Circuits I	4
GES	126	Engineering Computer Science	3
			16

Second Semester

ET	214	Statics/Dynamics	4
ET	256	Electric Circuits II	4
SH	101	Speech I	3
ET	260	Electronics I	4
		Humanities	2
			17

JUNIOR YEAR

First Semester

			Hours
ET	379	Thermodynamics and Heat Transfer	5
ET	311	Applied Mathematics III	2
ET	361	Electronics II	4
ET	355	Electrical Machinery	4
ET	358	Electromagnetic Fields	2
			17

Second Semester

ET	320	Engineering Materials	3
EH	419	Technical English	2
ET	358	Electric Energy Transmission	4
ET	362	Communications	2
		Humanities	4
			15

SENIOR YEAR

First Semester

ET	411	Legal Aspects of Engineering	3
EC	101	Economics	3
ET	471	Electrical Engineering Technology Project I	3
		Approved Technical Elective (EET)	3
		Electives	5
			17

Second Semester

ET	412	Management and Labor Relations	3
ET	458	Electrical Measurements	3
ET	472	Electrical Engineering Technology Project II	3
		Approved Technical Elective (EET)	3
EH	205	Literature	3
			15

VITA

William Byers was born in Ironton, Ohio on October 3, 19 After graduating from the Ironton Public Schools he enlisted in the U.S. Navy. His five years of military service included fleet duty in the Pacific Theatre, graduation from advanced electronics technician schcol and work with the Combined Research Group of the Naval Research Laboratory. After discharge he attended the University of Cincinnati and the Ohio State University where he received the Bachelor of Electrical Engineering degree.

His industrial experience has included three years with the Crosley Broadcasting Corporation in television station construction, operation and maintenance and four years with the General Electric Company in cathode ray tube display design and application and as District Engineer for television broadcast equipment. Subsequently he spent nineteen years with the Martin Marietta Corporation in assignments involving administration and supervision as well as individual technical responsibility for analog and digital computers, digital communications, radar display equipment, missile checkout, and automatic test equipment in design, development, manufacturing and field support and as a field test supervisor.

In 1968 he was selected to participate in the National Science Foundation supported Academic Year Institute at the Pennsylvania State University designed to prepare industry personnel as engineering technology faculty. His later teaching experience involved instruction of electronics technology at the Daytona Beach Community College, Seminole Junior College and Valencia Community College and as an adjunct professor in physics with Florida Southern College. In 1975 he was appointed to the faculty of the University of Alabama to teach in the Baccalaureate Engineering Technology programs.

He holds the Master of Business Administration degree with concentration in engineering management from Rollins College, the Master of Engineering and the Master of Education in General Engineering from the Pennsylvania State University and was enrolled as a candidate for the Doctor of Education degree, with specialization in Engineering Technology, at Nova University in 1973. He is a registered Professional Engineer in the State of Florida.